ENGINEERING DESIGN FILE

INEL

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Project File Number 168764
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Project/Task ARMF RADIOACTIVE SOURCE SHIPPING DRUM

Subtask Design Inputs, Analyses, Design Description

EDF Page 1 of 11

Title: ARMF RADIOACTIVE WASTE SHIPPING DRUM DESIGN

SUMMARY: The summary briefly defines the problem or activity to be addressed in the EDF, gives a summary of the activities performed in addressing the problem and states the conclusions, recommendations, or results arrived at from this task.

This EDF documents the design of a 55 gallon drum for transporting 4 radioactive sources from the Test Reactor Area's Advanced Reactivity Measurement Facility (ARMF) to the Radioactive Waste Management Complex (RWMC) for storage.

The shipping drum is similar in design to a DOT Spec 6M drum, with the exception that the inner container was replaced with a shielded container surrounded by steel piping, to provide sufficient shielding for the package to be accepted as "Contact-Handled Transuranic Waste" at the RWMC.

The Transport Plan is being reviewed and approved independently of this design activity. The Packaging and Transportation Department participated in the multidisciplined review of this design.

Distribution (complete package): A.N. Brown (MS4105), D.J. Bright (MS4201), S.J. Keating (MS7137), S.A. LaBuy (MS3921), M.J. Cordell (MS8103), W.A. Rhoades (MS5306), W.D. Wagner (MS3406), R.R. Williams (MS4113), D.J. Kenoyer (MS3921)

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Author S.A. LaBuy	Dept. Inactive Sites	Reviewed D.J. Kenoyer	Date 15-MAY-96	Approved E.F. Perry	Date 5/15/96
QA	5/16/96	LITCO Review	Date	LITCO Approval	Date

See Management Control Procedure (MCP) 6 for instructions on use of this form.

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INEL
Idaho National Engineering Laboratory

DOCUMENT MANAGEMENT CONTROL SYSTEM
DOCUMENT APPROVAL SHEET

FORM L-0103.E#
(Rev. 9-95)

Document Type: Design Input

Document Identifier: INEL-961137, EDF-ER-023

Title: ARMF Radioactive Source Shipping Drum

Author: S. A. LaBuy Phone: 526-9856

Document Owner: S. A. LaBuy Phone: 526-9856

REVIEW CONCURRENCE AND APPROVAL SIGNATURES
Denote R for review concurrence, A for approval, as appropriate

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Project/Task ARMF RADIOACTIVE SOURCE SHIPPING DRUM

Subtask **DESIGN INPUT**

The design requirements for the radioactive source shipping drum are presented below and the format of MCP-2371 was used as guidance. Design requirement references are presented in Appendix A.

1. REQUESTOR AND USER

Requestor - ARMF Deactivation Project

User - ARMF Deactivation Project (Loading and Shipping)
RWMC (Receipt and Storage)
TRA Maintenance Shop (Fabrication)

2. CURRENT PROBLEM

Four radioactive transuranic sources are stored in the TRA Advanced Reactivity Measurement Facility (ARMF) and need to be stored at RWMC for ultimate disposition at WIPP. No approved Type B packages are available that would provide sufficient shielding to meet 49CFR173 radiation limits for transport of the sources from TRA to RWMC. RWMC has requested that the package be contact handleable, which requires the design and fabrication of a shielded package. The four sources are described as follows:

Source	^{226}Ra-Be	^{226}Ra-Be	^{241}Am-Be	^{241}Am-Be
Identification	M-3RA001	M-3RA002	M-4AM003	unknown
Dimensions (in)	3/4" dia x 12" L	3/8" dia x 9" L	5/16" dia x 1/2" L	5/16" dia x 1/2" L
Mass (grams)	81.4	81.4	8.5	8.5
Last Assay Date	1/22/1973	1/22/1973	1/01/1980	unknown
Initial Activity (mCi)	600	56	10	10 (per label)
Calculated Alpha Activity of 1/01/96 (mCi)	594	55	9.8	9.8
Calculated Total Activity of 1/01/96 (mCi)	4478	418	9.8	9.8
Gamma Dose Rate on 1/01/96 (mR/hr) @ 1 ft. in air, point source	12,700	1,190	17	17
Decay Heat: 1/01/96 (mW)	106	9.9	3.2	3.2

a. Alpha activity, total activity, gamma dose rate, and decay power calculated by B. Schnitzler, BGS-02-96. The 10 mCi AmBe source with no inventory number is assumed to have the same characteristics as the known 10 mCi AmBe source.

b. The source records indicate the RaBe sources are 3/8" diameter x 9" long. The RaBe sources were measured underwater and the measured values are recorded above. The 600 mCi source appeared to have a sealed cladding surrounding it.

3. EXISTING SYSTEM

None

4. FUNCTION OF DESIRED END PRODUCT

A shipping package to transport a Type B quantity of radioactive sources from TRA to RWMC.

5. OPERATIONAL AND TECHNICAL REQUIREMENTS

A DOT Spec 6M Drum is used as the conceptual basis from which a detailed design for a shipping and storage package is being developed. The 6M Drum would not provide sufficient shielding for shipping, nor for RWMC contact handled packages. The design will meet as many 6M requirements, as possible, and will be a derivative of the 6M design. The referenced Design Requirement Documentation is provided in Appendix A.

5.1 Site Development - N/A

5.2 Structural -

The drum shall meet the general packaging requirements of 49CFR173.24.

The drum shall meet DOT Spec 17C, or equivalent (RWMC recommends UN1A2). The outer steel drum shall not be less than 10 gal. nor more than 110 gallons. (49CFR178.354-2) The RRWAC specifies a 55 gal. drum for CH-TRU and a 30 or 55 gal. drum for RH-TRU.

The package shall duplicate the 6M Drum construction to the maximum extent practicable as specified in 49CFR178.354-3. The following deviations are expected from the 6M design: the 6M weight limit will be exceeded, the drum vent will meet RWMC criteria, and the 2R inner vessel of the 6M drum will be replaced with a unique shielded design.

The package will be closed with a 16-ga. bolt-type locking ring and appropriate bolt. (49CFR178.354-4)

Sufficient shielding will be provided to satisfy 49CFR173.441 radiation level limitations of 200 mrem/hr at surface of package, or 1000 mrem/hr as an exclusive use shipment. RWMC has requested that sufficient shielding be provided to result in a contact handleable package (<200 mR/hr at the surface), if weight limits are not exceeded. Lead is not an acceptable shielding material, since the RRWAC does not allow RCRA waste in TRU packages; therefore, steel will be used as shielding.

The heat generated within the package shall not affect the integrity of the package and surface temperature will not exceed 122°F. (49CFR173.442)

The drum shall be approved for a one-time only on-site shipment of radioactive materials. (DOE 5480.3)
Transportation requirements are being addressed in a separate transportation plan. The ultimate transport from the INEL to WIPP will likely be in a TRUPACT-II Type-B shipping cask and does not result in any design inputs for the drum.

The package shall meet the weight requirements for CH-TRU (if <200 mR/hr) or RH-TRU (if >200 mR/hr). (INEL RRWAC for TRU)

The package shall meet all requirements specified in the INEL RRWAC for CH-TRU or for RH-TRU, as determined by the surface radiation levels.

5.3 Mechanical - N/A
5.4 Electrical - N/A
5.5 Instrumentation and Control - N/A
5.6 Architectural - N/A
5.7 Process - N/A

6. ANCILLARY CRITERIA

Design criteria that are desirable but not quantified are to minimize the package weight and maximum shielding (minimize surface dose rate for ALARA).

7. QUALITY LEVEL

The design and fabrication of a shipping package for on-site shipment of these radioactive sources is classified as "Quality Level 2". Procedure MCP-540 assigns a quality level (QL) based on safety analysis criteria. The activity level is less than Category 3 threshold levels as stated in DOE-STD-1027-92 and is a "low hazard activity", as defined in DOE 5481.1B, which would result in QL 3. However, the "Quality Program Plan for Hazardous Material Packaging and Transportation" states that QL 1 shall apply to the design and fabrication of a DOT Type B packaging. The 49 CFR 173.435 A_2 normal form value is 8 mCi for Am^{241} and 50 mCi for Ra^{226}. These sources are Type B quantities since their activities exceed the A_2 normal form values. A determination was made to classify the design and fabrication as QL 2 based on the stringent on-site controls for packaging and transportation activities. A QL 2 fabrication inspection is comparable to a QL 1 and the dimensional specifications are more critical than material certifications.

8. RISK CATEGORY

The design and fabrication of the shipping package is "low-risk".

9. NATURAL PHENOMENA HAZARD CLASSIFICATION, LOAD CRITERIA, AND PERFORMANCE CATEGORY

N/A. No criteria are applicable to seismic or other natural phenomena.

10. APPLICABLE EXISTING DRAWINGS, SPECIFICATIONS, VENDOR DATA SHEETS, ANALYSIS, ETC.

Inspection, Testing, and Operating Requirements for Packaging and Shipping of Type B Quantities of Radioactive Materials in DOT Spec 6M Packagings, ES-51526, Rev. B provides information beneficial to the design of this drum.

11. APPLICABLE CODES, STANDARDS, and REGULATORY REQUIREMENTS

49CFR173
49CFR178
RWMC Waste Acceptance Criteria

DOE 5480.3 for On-Site Shipments.

12. QUALITY, SECURITY, and ES&H REQUIREMENTS

The design requirements relative to quality, security, and ES&H are addressed previously in this document.

13. ASSUMPTIONS

The 10 mCi AmBe source with no inventory number is assumed to have the same characteristics as the inventoried 10 mCi AmBe source.

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DOCUMENT MANAGEMENT CONTROL SYSTEM
DOCUMENT APPROVAL SHEET

Document Type: ENGINEERING ANALYSIS

Document Identifier: INEL-961137 EDF-ER-023

Title: SHIELDING CALCULATIONS

Author: S. A. LaBuy Phone: 6-9856

Document Owner: S. A. LaBuy Phone: 6-9856

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S. A. LaBuy - Requestor S. A. LaBuy	A	5/10/96	Inactive Sites / 3110	MS 3921

Project/Task ARMF RADIOACTIVE SOURCE SHIPPING DRUM

Subtask **ENGINEERING ANALYSIS - SHIELDING CALCULATIONS**

The shielding calculations for the drum are presented below. The format of MCP-2374 was used as guidance.

ANALYSIS PLAN

1. PURPOSE

The purpose of the shielding calculation is to determine the size of shipping drum needed and the amount of shielding necessary to reduce the package surface dose rates to less than 200 mR/hr. The weight of the drum is determined at the optimal shielding configuration to ensure it is within RRWAC limits.

2. DESCRIPTION OF ITEM TO BE ANALYZED

See Design Inputs.

3. IDENTIFICATION OF APPLICABLE DOCUMENTATION

Microshield 4.21, Grove Engineering.

4. IDENTIFICATION OF DESIGN REQUIREMENTS

See Design Inputs.

5. DESCRIPTION OF SAFETY SIGNIFICANCE OR CATEGORY

Low Hazard Activity per DOE Order 5481.1B.

6. DOCUMENT CATEGORY

Category 3, per MCP-135.

ANALYSIS

1. Author - S. A. LaBuy
   Verifier - W. D. Wagner

2. Analysis Input:

See Design Inputs. The drum configuration and dimensions presented in the design description, and shown in Appendix D, are used as the basis for the shielding calculations presented below.

3. Analysis Objective: See Analysis Plan above.

4. Analysis Method:

Microshield 4.21 is used to estimate the exposure rate at the drum surface due to gamma radiation produced by the Ra226 daughter products. Microshield calulates the daughter product inventory by decaying the original Ra226 content. The exposure rate is calculated at the side, top, and bottom of the drum. A hand calculation is used to estimate the neutron exposure at the drum surface. The neutron dose is a result of the Be(α,n) reaction.

5. Assumptions and identification of assumptions that must be verified as the design proceeds:

The AmBe sources are neglected in the shielding calculations since the AmBe gamma dose rate is 0.1% that of the strongest RaBe source. The gamma contribution of the AmBe source to the total exposure is neglible with the proposed shielding thicknesses.

The microshield calculations used the last air gap as the selected medium for buildup factors. Scoping calculations used the steel shielding as selected medium for buildup factors and resulted in lower dose rates at the drum surface. As a conservatism, air is the selected medium.

The microshield input files do not allow the input of wood as a shielding medium. Air was used in scoping calculations and the final calculations use carbon as a shield, which has a similar atomic number (Z value) of wood. The actual density (0.32 g/cm^3) of fiberboard is used, instead of that of carbon.

The gamma dose from activation of steel (n,γ) is neglected because of the low neutron fluences and the short half life of Fe-59.

The neutron dose calculation uses the "removal cross-section" concept, which is valid for water or a hydrogenous material following the primary shielding. This drum uses wood following the steel, which is hydrogenous, but not as effective as water. This is an acceptable approach since the calculated neutron dose rate is 2 mrem/hr and any correction would be a small factor of this total.

6. Calculations by Subject:

The Microshield 4.2 calculations are presented in Appendix B.
The neutron exposure hand calculation is presented in Appendix C.
The drum weight calculation is presented at the end of this Section.

7. Analysis Results:

Scoping calculations indicated that a 30 gallon drum did not provide sufficient distance from the sources to the package surface to reduce the dose rate. Therefore, all shielding calculations were performed with a 55 gallon drum.

The calculated gamma exposure rate is 173 mrem/hr at the side of the drum, with 4.8 inches of steel shielding.

The calculated gamma exposure rate is 79 mrem/hr and 123 mrem/hr at the top and bottom of the drum, respectively. These data are a result of 3.3 inches of steel above the source and 3.8 inches below the source.

Scoping calculations were also performed to determine the effect of time on the daughter product

activities. Some daughter products tend to build up over time which could potentially increase the surface dose rates in the outyears. A microshield case was run for a Ra226 decay period of 28 years, which resulted in a surface dose rate of 173 mrem/hr, which is the same as the current estimated dose rate. This is because the primary gamma emitters, Bi^{214} and Pb^{214}, are in equilibrium and will not increase in activity over time.

The neutron dose is estimated to be minimal with this shielding configuration. The neutron dose rate at the side of the drum is estimated to be 2 mrem/hr.

The weight of the drum is calculated to be approximately 850 lbs.

8. References: None.

	CALCULATION OF WEIGHT AND WALL THICKNESS							
			OD	ID	Height	Density	Weight	Wall
ITEM	Material	Qty	(in)	(in)	(in)	(lb/ft3)	(lbs)	Thickness
6" Sch 40	Steel	1	6.625	6.065	21	489	33.2	0.28
8" Sch 120	Steel	1	8.625	7.187	21	489	106.1	0.719
10" Sch 120	Steel	1	10.75	9.062	21	489	156.0	0.844
12" Sch 100	Steel	1	12.75	11.062	21	489	187.5	0.844
DRUM	Steel	1					60.0	0.06
Shield Plug	Steel	1	5.75	0	2.5	489	18.4	
Canister	Steel	1	5.75	1.75	17.5	489	119.3	2
Bearing Plates	Steel	2	22	0	0.25	489	53.8	
Wood -Ends	Fiberboard	6	22.5	0	1.75	20	48.3	
Wood -Middle	Fiberboard	12	22.5	13.5	1.75	20	61.8	
					TOTAL		844.3	4.747
	Weight = 3.14*((OD^2-ID^2)/4)*Ht*Density/1728 in3/ft3							
	Wall Thickness = (OD-ID)/2							

DATE: 4/10/96

BY: S. LaBry
Scott LaBry

CHECKED: DJ KENDAER 09-MAY-96

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Idaho National Engineering Laboratory

DOCUMENT MANAGEMENT CONTROL SYSTEM
DOCUMENT APPROVAL SHEET

FORM L-0103.E#
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Document Type: Design Description

Document Identifier: INEL-961137, EDF-ER-023

Title: ARMF Radioactive Source Shipping Drum

Author: S. A. LaBuy Phone: 526-9856

Document Owner: S. A. LaBuy Phone: 526-9856

REVIEW CONCURRENCE AND APPROVAL SIGNATURES
Denote R for review concurrence, A for approval, as appropriate

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A. N. Brown	R	5/15/96	Packaging and Transportation	MS ~~4113~~ 4105
D. J. Bright	R	5/14/96	Waste Management	MS 4201
S. A. LaBuy	A	5/15/96	Inactive Sites	MS 3921

Project/Task ARMF RADIOACTIVE SOURCE SHIPPING DRUM

Subtask DESIGN DESCRIPTION

DESIGN OBJECTIVE

The purpose of the enclosed design is to package four radioactive transuranic sources for shipment from TRA to the RWMC, for ultimate disposition at WIPP.

CONCEPTUAL DESIGN APPROACH

The conceptual approach is to provide sufficient shielding to satisfy shipping criteria (dose rate limit) and the INEL RRWAC (dose rate limit and weight restriction).
The unshielded RaBe sources are classified as RH-TRU (>200 mR/hr).
The RRWAC dose rate limits are 30 R/hr for RH-TRU and 200 mR/hr for CH-TRU.
The DOT dose rate limits are 200 mR/hr at the surface of the package, or 1 R/hr if shipped as an exlusive use shipment. If 1 R/hr could not be obtained, the CNS 1-13 cask would be used to transport the drum to RWMC, which would require a transport plan update.
RWMC has requested the package be contact handleable, if technically feasible, and if the package can meet the weight limit criteria.
The weight limit for RH-TRU is 800 lbs and for CH-TRU is 1000 lbs, per the RRWAC.

The 55 gal. DOT Spec. 6M drum has a 5 in. diameter inner canister to place the sources. The conceptual approach is to place the sources in a shielded container, for placement into the 6M drum as the inner container. The RRWAC does not allow the use of lead in the packaging; therefore, steel has been selected to decrease the surface dose rate to less than 200 mR/hr.

Scoping calculations indicate that about 5 in. of steel, in a 55 gal. drum, will be required to decrease the surface dose rate to less than 200 mR/hr. This amount of steel does not result in a package weight that exceeds the 1000 lb weight limit. The RWMC Generator Interface (GI) indicated that this approach does not violate the RRWAC and that it is acceptable to remove the inner canister from the 6M and enlarge the opening, by cutting out the fiberboard to a larger diameter hole to allow sufficient shielding. This approach does require the preparation and approval of a Transport Plan for shipping a Type-B quantity of material in an unapproved DOT packaging. Note: Approximately 2.5 in. of steel, in a 55 gal. drum, is required to decrease the dose rate to less than 1000 mR/hr.

As an alternative, a concrete filled drum was evaluated. A concrete filled drum reduces the dose rate to within limits, however, the RWMC weight limits would be exceeded.

DESIGN DESCRIPTION

The design fabrication drawings are shown in Appendix D. The drum configuration has 4.75 inches of axial steel shielding, in the form of steel bar stock and steel piping. The maximum calculated dose rate is estimated to be approximately 175 mR/hr at the surface of the package. The drum weight is 844 lbs. This configuration satisfies the RWMC receipt criteria for CH-TRU.

Similar to the DOT Spec. 6M drum, this drum design utilizes standard industrial cane fiberboard surrounding the inner container, and on the top and bottom of the drum. A 0.25 in. thick steel bearing plate is located directly above and below the inner container to distribute the weight and prevent damage to the fiberboard. Steel piping is slip fit around the inner shield plug to provide sufficient

radiation shielding. The RWMC GI indicated that carbon steel piping was acceptable, which reduces the materials cost. TRA has excess stainless steel bar stock, which resulted in the specification of stainless steel for the shield container. The 55 gal. drum is the minimum size that provides sufficient distance to aid in decreasing the surface dose rate. Discussions with the RWMC GI resulted in the specification of a white UN-1A2 drum instead of a DOT Spec. 17C, in anticipation of future WIPP requirements.

The RRWAC requires all TRU containers to be vented. Therefore, the source shield container provides a 0.25" diameter hole, positioned to prevent radiation streaming, yet allow sufficient venting. Each bearing plate will have two 1 in. diameter holes located to allow venting from between the storage canister and the 6 in shield pipe. The DOT Spec 6M vent requirements are not required for this shipment. The drum will be vented to allow release of hydrogen gas, as required by the RRWAC. The drum vent will be an approved carbon composite filter (NucFil™ or equivalent) and is not shown on the fabrication drawings. The vent will be installed prior to shipment as required by RWMC.

APPENDIX A

DESIGN REQUIREMENT REFERENCES

4.8 Transuranic Waste

4.8.1 General

The following acceptance criteria shall apply to all transuranic waste to be stored at the Radioactive Waste Management Complex (RWMC). These criteria apply in addition to the criteria noted in the appropriate Subsections 4.8.2 and 4.8.3.

NOTE *Due to the uncertainty of the WIPP-WAC final requirements and the restrictive criteria of TRUPACT-II transportation requirements, contact the appropriate RWMC GI at 6-7711 or 6-2954 before generating or packaging TRU waste.*

1. Offsite non-INEL generators are required to be authorized by the Department of Energy Idaho Operations Office (DOE-ID) before sending TRU waste for storage at the RWMC.

2. Annual update of Form EG&G-1645, "Solid Radioactive Waste Forecast for Waste to be Treated, Stored, or Disposed at the Idaho National Engineering Laboratory," (due annually during the third quarter of each fiscal year) is on file with:

   WASTE FORECASTS
   MS 3922
   Lockheed Idaho Technologies Company
   P. O. Box 1625
   Idaho Falls, ID 83415-3922.

3. A completed INEL Form L-0669 for each waste stream has been approved by the receiving organization.

4. Radioactive Waste Management Information System (RWMIS) computer generated Form ID F-5820.2, "Stored, Disposed, or Processed Solid Radioactive Waste," completed electronically for each waste package before shipment [Best Management Practice (BMP)].

   NOTE *The INEL-RWMIS Solid Waste Data Users Manual, DOE/ID-10188, provides instructions for remote data entry for Form ID F-5820.2.*

5. Nuclear accountability documentation, as applicable, is sent to the special nuclear materials accountability program (BMP) (ID letter, MC and A Reporting Procedures for Waste Data, dated August 29, 1983, H. R. Martin, Chief Safeguard and Materials Management Branch).

   NOTE *Nuclear accountability documents do not accompany waste shipments.*

6. The following documentation accompanies each shipment:

   a. Form ID F-5820.2A, "Certified Waste Data Base System Transuranic Waste Data Base Input," completed for each waste package (INEL RCRA Permit).

   b. A Waste Isolation Pilot Plant Waste Acceptance Criteria (WIPP-WAC) Certification Statement for each package of WIPP certified waste (WIPP-WAC)

c. An approved Form ID F-669A, "Shipment Request and Certification" (BMP)

d. Properly completed Shipping Papers

7. Waste does not contain

a. Pressurized containers that are not vented, drained, crushed, or otherwise reconfigured to allow verification via real-time radiography (WIPP-WAC)

b. Radioactive materials in a gaseous state, or in a host medium that will permit such gas to be liberated by the RWMC ambient temperature cycles ranging from -50° F to 110° F and pressure cycles ranging from 24 to 26 inches of mercury (WIPP-WAC)

c. Classified waste materials (DOE Order 5820.2A)

d. Free liquid (DOE Order 5820.2A)

e. Resource Conservation and Recovery Act (RCRA) listed hazardous waste (40 CFR 261)

f. PCBs ≥50 ppm (BMP)

g. Etiologic agents (RWMC SAR)

h. Materials capable of generating toxic gases, vapors, or fumes (BMP)

i. Sealed containers (WIPP-WAC)

j. Any inner containers of waste with volumes greater than 4 liters unless a relief valve has been blocked open on such inner containers or they have been visibly punctured [TRUPACT-II authorized methods for payload control (TRAMPAC)]

k. Compressed gas containers (WIPP-WAC)

l. Chelating and complexing agents, except residue material (DOE Order 5820.2A)

m. Radioactive pyrophorics ≥ 1 wt% (WIPP-WAC).

8. Absorbents and stabilizing agents used to eliminate free liquids have undergone generator's bench-scale testing that demonstrates

a. Performance is as specified by the vendor, or an improved specific use methodology has been developed (BMP)

b. Liquids do not separate from the absorbents or stabilizing agents due to ambient temperature cycles ranging from -50° F to 110° F and pressure cycles ranging from 24 to 26 inches of mercury (DOE Order 5820.2A).

9. Dry loaded waste packages such as drums, boxes, or inserts having a potential for free liquid have

   a. An optimum absorbent or stabilizing agent, as determined in Item 8 above, used to ensure immobilization of free liquid (BMP)

   b. Absorbent and stabilizing agents placed inside the innermost waste bag or container where the free liquid is suspect (BMP)

   c. Absorbent and stabilizing agents placed as close as practical to inaccessible liquid (BMP).

10. Waste is not

   a. RCRA characteristic ignitible waste (D001) (40 CFR 261.21)

   b. RCRA characteristic corrosive waste (D002) (40 CFR 261.22)

   c. RCRA characteristic reactive waste (D003) (40 CFR 261.23)

   d. RCRA characteristic toxic waste (D004) (40 CFR 261.24)

   e. RCRA listed F, P, K, or U waste

   f. Pyrophoric as defined in 49 CFR 173.124(b)(1), or Department of Transportation (DOT) Class 1 (formerly Class A, B, or C) explosive, or unstabilized shock-sensitive reactive as determined by the receiving organization generator interface (RWMC SAR)

   g. Readily capable of detonation, explosive decomposition or reaction at normal pressures and temperatures, or explosive reaction with water (DOE Order 5820.2A)

   h. Spent nuclear fuel or high-level waste (DOE Order 5820.2A).

11. Surface contamination on each TRU waste package and transport device does not exceed 200 dpm/100 cm^2 beta/gamma or 20 dpm/100 cm^2 alpha (*INEL Radiological Control Manual*, DOE/ID-10399).

12. Waste packages are provided with lifting devices or permanently attached handling features (*DOE Hoisting and Rigging Manual*).

13. Lifting rings and other auxiliary lifting devices on the package are recessed, offset, or hinged in a manner that does not inhibit stacking (*DOE Hoisting and Rigging Manual*).

14. Waste packages requiring rigging for crane lifts are prerigged and specified on a case-by-case basis (*RWMC Part B permit application*).

15. Special hoisting and rigging requirements provided by the waste receiving facility are met (BMP).

16. Bulky and heavy items are blocked and/or braced inside the waste containers to prevent a shift of the waste that may reduce the effectiveness of the package during transport and handling [49 CFR 173.24(b)(2)].

17. The fissionable-material limits as stated in Table 4.8.1-1 are met as applicable (RWMC SAR).

NOTE *Due to the evolving nature of TRU waste regulations, generators should contact the appropriate GI to obtain current material packaging and transportation limits.*

Table 4.8.1-1. TRU Waste Fissile Material Concentration Limits (RWMC SAR)

Matrix Group	TVC[a]	TRU Content Codes[b]									
Polyethylene	3.10	3, 112,	123, 153,	202, 332,	337, 339,	423, 432,	460, 463,	700, 802,	804 812		
Cellulose	1.30	10, 116, 119,	120, 121, 153,	203, 302, 328,	330, 331, 334,	335, 336, 338,	360, 361, 375,	376, 438, 464,	490, 491, 801,	805, 826, 827,	847, 900, 970
Metal(Al)[c]	0.82	20, 101,	117, 155,	156, 201,	320, 321,	333, 416,	480, 481,	482, 488,	803, 824,	825, 950	
Concrete	0.56	1, 2, 4,	15, 95, 111,	113, 122, 152,	154, 157, 200,	204, 290, 292,	295, 299, 374,	701, 702, 811,	812, 836, 960,	976, 978, 980,	995,
Brick	0.23	371,	373,	377,	378,	379					
Glass/slag	0.09	7, 30, 40, 69, 105,	90, 100, 102, 241,	114, 118, 150, 390,	368, 370, 372, 420,	391, 392, 393, 440,	421, 422, 425, 483,	441, 442, 470, 955	810, 813, 834,	990,	
Graphite	0.02	115,	300,	301,	303,	310,	311,	312,	814		
Salts	5.53	5,	124,	409,	410,	411,	412,	413,	414,	429,	454
DOT 6M Shipping Pkg		Less than or equal to 300 g/pkg (RH only)									

a. Threshold Value Concentration (fissile grams/pound matrix).
b. Content code assignment is accomplished through INEL Form L-0669 processing.
c. Threshold value calculated on aluminum.
d. Waste with fissile concentrations greater than the TVC must be packaged in 6M Shipping Packages (ES-51526). Blending with lower TVC from the same waste stream is allowed.

18. Radiation limits shall not exceed those specified in Tables 4.8.2-1 and 4.8.3-1 as applicable (WIPP-WAC).

19. Neutron contributions > 20 mrem/hr are separately documented (WIPP-WAC).

20. Waste packages are (a) chemically and structurally stable (49 CFR 173.24), and (b) closed, no leakage (49 CFR 173.24, 173.411, 173.412, 173.425, 173.475).

21. The total concentration of potentially flammable volatile organic compounds is ≤ 500 ppm in the headspace of a payload container (TRAMPAC).

22. Radiation levels defined in these criteria are verified by the generator with radiation survey instrumentation calibrated at least semiannually (BMP).

23. Radiation levels of waste packages are verified by the RWMC receiving organization to agree with those reported by the waste generator at the time of shipment, to within the following amounts (RWMC Part B application):

    a. ± 100% for reported levels ≤ 10 mR/h

    b. ± 20% for reported levels > 10 mR/h.

24. Each container is vented (one vent per drum and two vents per standard waste box) to allow release of hydrogen gas (contact TRU GI for assistance) (WIPP-WAC):

    a. The container vent is an approved carbon composite filter (NucFil™ or equivalent).

    b. The container vent installation date is recorded and used to determine the aspiration period required before shipment.

    c. Container liner has a ≥ 0.3-in. vent hole or is filtered.

25. Individual waste packages do not exceed 1,000 Ci of Pu-239 equivalent activity (WIPP-WAC).

26. Nonimmobilized/nonstabilized particulates < 10μ in diameter do not exceed 1 wt% of the waste (WIPP-WAC).

27. Nonimmobilized/nonstabilized particulates < 200μ in diameter do not exceed 15 wt% of the waste (WIPP-WAC).

28. Packages must pass 49 CFR 173.475 quality control inspection requirements.

29. Gas generation is limited to prevent the accumulation of flammable mixtures and pressure buildup in the transport device (TRAMPAC).

30. The layers of plastic containment are known and minimized (TRAMPAC).

31. Bags are closed using the twist/tape or fold/tape method (WIPP-WAC).

32. Total decay heat plus error are calculated and recorded in the data package for each container (WIPP-WAC).

33. Internal waste container void volume, excluding the annulus between any overpack and the original container, does not exceed 15%. Void space shall be filled with appropriate radioactive waste as practicable (RWMC Part B application).

    NOTE *Determination of void volume considers the actual density of the waste material. Reduction of void volumes resulting from container design are the responsibility of the container design owner, and will be assessed for improved design.*

34. Waste packages do not leak contents (49 CFR 173.24, 173.411, 173.412, 173.425, and 173.475)

35. Isotopes that are detected with a true-positive indication are reported. Isotopes below 0.1 pCi/g alpha and beta and less than 1.0 pCi/g gamma are not required to be reported (BMP).

    NOTE *This reporting guidance is not to be misconstrued as a definition of nonradioactive or as unrestricted release limits.*

36. Instruments, equipment, and procedures used for isotope detection and quantification are comparable to those used at the INEL Radiation Measurements Laboratory and appropriate for the respective radionuclides to be detected (BMP).

37. Tritium waste has been prepared for storage to prevent exceeding an equivalent package release rate of 40 $Ci/m^3/y$ (BMP).

38. Wastes within a container are compatible with each other and with the packaging materials and this compatibility is documented [TRUPAC, 49 CFR 173.24(e), 177.848, and 40 CFR 264.17].

39. Exterior surfaces of waste packages are free of ice, snow, and dirt (INEL RCRA Permit).

40. A nonstandard package from an existing waste stream in a new waste stream (INEL RCRA Permit).

4.8.2 Contact-Handled, Transuranic Waste to be Stored at the Radioactive Waste Management Complex

In addition to meeting all the criteria of Subsection 4.8.1, the following acceptance criteria shall also be met before shipping contact-handled, TRU waste to the RWMC for storage.

1. Contact-handled, TRU waste generated by non-INEL generators that forecast/generate more than 25 m^3 of such waste per year is certified to the WIPP-WAC (including TRAMPAC) certification requirements by the generator (DOE-HQ Program Guidance to DOE-ID, 1987).

2. Contact-handled TRU waste generated by INEL generators is certified to Section 4.8 of the INEL RRWAC and is certifiable to the WIPP-WAC (BMP).

3. The waste is packaged in one of the following standard containers: (WIPP-WAC)

   a. DOT 17C, or UN 1A2 55-gal Drum

   b. 6M Shipping Packages (ES-51526)

   c. DOT 7A Type A, TRUPACT II Standard Waste Box.

4. Markings for contact-handled TRU waste packages includes

   a. Markings that are legibly printed, stenciled, or neatly hand-lettered (49 CFR 172, Subpart D).

   b. Removal of any extraneous markings such as freehand spray paint markings or graffiti of any kind (BMP).

   c. Proper DOT markings (49 CFR 172, Subpart D) and labels in accordance with 49 CFR 172, Subpart E.

   d. Waste package gross weight [49 CFR 172.301(d)].

   e. Shipper's complete name and address [49 CFR 172.301(d)].

   f. Shipper's unique identification number, the first two digits of which are the last two digits of the current calendar year and the last three digits are the container number. A new sequence of container numbers (commencing with 001) is initiated each January 1, or as approved by the GI (BMP).

   g. Maximum radiation level at contact and at 1 m in air (49 CFR 172.403).

   h. Placement of one full set of labels and markings on the top and appropriate side(s) of each container so that one full set of labels and information for each container shall always be visible (BMP).

5. Waste packages comply with the requirements of Table 4.8.2-1.

4.8.2 Contact-Handled, TRU Waste to be Stored at the RWMC (continued)

Table 4.8.2-1. Contact-handled, transuranic waste to be stored at the RWMC.

Characteristic	DOT 17C, or UN 1A2 55 gal-Drum	TRUPACT II Standard Waste Box	Criterion basis
Gross weight	≤ 1,000 lb/drum	≤ 4,000 lb/box	(Design)
Dimension	55 gal	55 × 71 × 37 in. high	(Design)
Surface radiation	≤ 200 mR/h	≤ 200 mR/h	(BMP)
Fissionable material[a]	≤ Table 4.8.1-1 limits, and ≤ 200 g/drum	≤ Table 4.8.1-1 limits, and ≤ 5g/ft^3, ≤ 325 g/box	(RWMC SAR) (TRAMPAC)
TRU content	> 100 nCi/g	> 100 nCi/g	(DOE 5820.2A)
Thermal power[b]	≤ 0.1 W/ft^3 (3.5 W/m^3)	≤ 0.1 W/ft^3 (3.5 W/m^3)	(TRAMPAC)
Liner	90-mil rigid polyethylene[c]	NA	(BMP)
Container bags[d]	minimize	minimize	(TRAMPAC)
Tamper indicating device (TID)	Yes[e]	Yes	(BMP)
Lid gasket watertight	No leakage[f]	No leakage[g]	(49 CFR 173.24)

a. Fissionable material limits are based on assumed low-density waste contaminated with small amounts of volumetric averaged fissionable material. Low-density waste is waste consisting of materials such as paper, polyethylene wrap, tape, glass, rags, blotting paper, scrap metal, and piping etc. Volumetric average is defined as concentration obtained by dividing the total fissionable material content of a container by its volume. The fissionable material limit is the limit listed in the table minus twice the absolute value of the error for the measuring equipment used.

b. Individual, contact-handled TRU waste packages in which the average thermal power density exceeds 0.1 W/ft^3 (3.5 W/m^3) shall have the thermal power recorded in the data package.

c. A rigid polyethylene liner per procurement specification ES-50357, shall be used inside each DOT 17C Drum.

d. To reduce pyrolitic gas generation, the number of poly bags shall be minimized, the 90 mil poly liner is exempt. The drum bag is the first to be counted, also avoid the use of hydrogenous packaging materials.

e. Each container shall have a TID installed by the waste generator in such a manner as to preclude removal of the lid without destroying the TID.

f. The lid gasket shall be coated with Permatex™ No. 2 nonhardening adhesive, or equivalent, applied to the seal areas.

g. Neoprene gasket (1-1/2-in.-wide × 1/2-in.-thick).

4.8.3 Remote-Handled, Transuranic Waste to be Stored at the Radioactive Waste Management Complex

In addition to meeting all of the criteria of Subsection 4.8.2 except for the surface radiation reading limit, the following acceptance criteria shall also be met before shipping remote-handled, TRU waste to the RWMC for storage.

1. Remote-handled waste, without exception, is certified to the WIPP-WAC (including TRAMPAC) and reusable property, recyclable materials, and waste acceptance criteria certification requirements by the waste generator [DOE-ID Memorandum, "Accept only certified (CH) or certifiable (RH) TRU waste at the TRU storage facility." "Subsequent to May 1988, only WIPP certified RH-TRU waste will be accepted," May 19, 1987.]

2. Waste is packaged in any of the following standard containers:

   a. DOT 17C, or UN 1A2 55-gal Drum

   b. DOT 17H, or UN 1A2 30-gal Drum

   c. 6M Shipping Packages (ES-51526)

   d. Hot Fuel Examination Facility (HFEF)-5 Waste Canister (DOE-ID approved).

3. Remote-handled waste containers are labeled with a permanently affixed container identification number located on top of the container which is visible and legible through remote, visual verification equipment and is directly traceable to waste package content documentation (INEL RCRA Permit).

4. Waste packages comply with the requirements of Table 4.8.3-1.

Table 4.8.3-1. Remote-handled, transuranic waste to be stored at the RWMC.[a]

Characteristic	DOT 17H or UN 1A2 drum	HFEF-5 Waste Canister	Criterion basis
Gross weight	≤ 400 lb/drum[b]	≤ 1,000 lb/canister	(Design)
Dimension	30-gal drum	12.375 in. dia × 74.5 in. high	(Design)
Radiation at surface	> 200 mR/h ≤ 30 R/h[c]	> 200 mR/h < 1,000 R/h[d]	(BMP)
TRU content	> 100 nCi/g	> 100 nCi/g	(RWMC SAR)
Fissionable material[e]	≤ Table 4.8.1-1 limits and ≤ 100 g/drum	≤ Table 4.8.1-1 limits and ≤ 200 g/can	(RWMC SAR and DOE 5820.2A)
Thermal power[f]	≤ 300 W/drum	≤ 300 W/canister	(RWMC SAR)
Inner container	Sealed metal or poly containers[g]	14-gauge stainless steel	(WIPP-WAC)
Liner	Poly blow molded[h]	NA	(Design)
TID	Yes[i]	Seal welded or eutectic metal poured over head clamp	(BMP)

4.8.3 Remote-Handled, TRU Waste to be Stored at the RWMC (continued)

Table 4.8.3-1. (continued).

Characteristic	DOT 17C or UN 1A2 drum	6M Shipping Packages (ES-51526)	Criterion basis
Gross weight	≤ 800 lb/drum	≤ 640 lb/package	(Design)
Dimension	55-gal/drum	55/100-gal/package	(Design)
Radiation at surface	> 200 mR/h ≤ 30 R/h[b]	> 200 mR/h ≤ 30 R/h[c]	(BMP)
Fissionable material[e]	≤ Table 4.8.1-1 limits and ≤ 200 g/drum	≤ Table 4.8.1-1 limits and ≤ 500 g/package	(RWMC SAR and WIPP-WAC)
TRU content[b]	> 100 nCi/g	> 100 nCi/g	(DOE 5820.2A)
Thermal power[f]	≤ 300 W/drum	≤ 300 W/package	(WIPP-WAC)
Inner container	NA	DOT 2R container	(DOT)
Liner	90-mil rigid poly[j], or DOT 17H or UN 1A2 drum	NA	(Design)
TID	Yes[i]	Yes[i]	(BMP)

a. Remote-handled, TRU waste shall be WIPP-certified and containers vented before shipment authorization.

b. This 400-lb limit is a handling limitation capacity at the RWMC.

c. Upper radiation limit based on INEL free-air transfer safety considerations.

d. Bottom discharge cask waste activity is subject to shielding calculations ensuring gamma radiation fields of less than 1 mR/h at 3 ft above the storage vault. Calculations are the responsibility of the waste generator and are subject to the RWMC approvals. Remote-handled, TRU waste packages shall have a surface dose rate at any point no greater than 1,000 R/h. Neutron contributions are limited to 270 mR/h. Neutron contribution of greater than 20 mR/h to the total package dose rate shall be reported in the data package. Approval is required before remote-handled, TRU waste canisters with a dose rate in excess of 100 R/h, but less than 1,000 R/h may be shipped.

e. Fissionable material limits are based on assumed low-density waste contaminated with small amounts of volumetric averaged fissionable material. Low-density waste is waste consisting of materials such as paper, polyethylene wrap, tape, glass, rags, blotting paper, scrap metal, and piping etc. Volumetric average is defined as concentrations obtained by dividing the total fissionable material content of a container by its volume. The fissionable material limit is the limit listed in the table minus twice the absolute value of the error for the measuring equipment used.

f. The thermal power generated by waste materials in any remote-handled, TRU waste package shall not exceed 300 watts. The thermal power shall be recorded in the data package.

g. Watertight sealed metal (26-gauge minimum wall thickness) or polyethylene containers (0.105-in. minimum thickness) enclosed in a twist/tape or fold/tape closed, or heat sealed and vented 0.020-in.-thick PVC sleeve.

h. Puncture-proof liner (0.100-in. minimum wall, blow-molded polyethylene with 0.06-in. thick minimum, plain disc cover), enclosed in a twist/tape or fold/tape closed, 0.020-in.-thick PVC liner. Puncture-proof liner obtainable from Container Corporation of America, Plastics Division, 30-gal CK Tank No. 1829.

i. Each container shall have a TID installed by the shipper so as to preclude removal of the head without destroying the TID.

j. A rigid polyethylene liner, per procurement specification ES-50357, shall be used inside the DOT 17C Drum.

Section 173.24 General requirements for packagings and packages.

(a) Applicability. Except as otherwise provided in this subchapter, the provisions of this section apply to-

(1) Bulk and non-bulk packagings;

(2) New packagings and packagings which are reused; and

(3) Specification and non-specification packagings.

(b) Each package used for the shipment of hazardous materials under this subchapter shall be designed, constructed, maintained, filled, its contents so limited, and closed, so that under conditions normally incident to transportation-

(1) Except as otherwise provided in this subchapter, there will be no identifiable (without the use of instruments) release of hazardous materials to the environment;

(2) The effectiveness of the package will not be substantially reduced; for example, impact resistance, strength, packaging compatibility, etc. must be maintained for the minimum and maximum temperatures encountered during transportation;

(3) There will be no mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure, significantly reduce the effectiveness of the packaging.

(c) Authorized packagings. A packaging is authorized for a hazardous material only if-

(1) The packaging is prescribed or permitted for the hazardous material in a packaging section specified for that material in Column 8 of the Section 172.101 Table and conforms to applicable requirements in the special provisions of Column 7 of the Section 172.101 Table and, for specification packagings (but not including UN standard packagings manufactured outside the United States), the specification requirements in parts 178 and 179 of this subchapter; or

(2) The packaging is permitted under, and conforms to, provisions contained in Sections 171.11, 171.12, 171.12a, 173.3, 173.4, 173.5, 173.7, 173.27, or 176.11 of this subchapter.

(d) Specification packagings and UN standard packagings manufactured outside the U.S.-(1) Specification packagings. A specification packaging, including a UN standard packaging manufactured in the United States, must conform in all details to the applicable specification or standard in part 178 or part 179 of this subchapter.

(2) UN standard packagings manufactured outside the United States. A UN standard packaging manufactured outside the United States, in accordance with national or international regulations based on the UN Recommendations on the Transport of Dangerous Goods, may be imported and used and is considered to be an authorized packaging under the provisions of paragraph (c)(1) of this section, subject to the following conditions and limitations:

(i) The packaging fully conforms to applicable provisions in the UN Recommendations on the Transport of Dangerous Goods and the requirements of this subpart, including reuse provisions;

(ii) The packaging is capable of passing the prescribed tests in part 178 of this subchapter applicable to that standard; and

(iii) The competent authority of the country of manufacture provides reciprocal treatment for UN standard packagings manufactured

in the U.S.

(e) Compatibility. (1) Even though certain packagings are specified in this part, it is, nevertheless, the responsibility of the person offering a hazardous material for transportation to ensure that such packagings are compatible with their lading. This particularly applies to corrosivity, permeability, softening, premature aging and embrittlement.

(2) Packaging materials and contents must be such that there will be no significant chemical or galvanic reaction between the materials and contents of the package.

(3) Plastic packagings and receptacles. (i) Plastic used in packagings and receptacles must be of a type compatible with the lading and may not be permeable to an extent that a hazardous condition is likely to occur during transportation, handling or refilling.

(ii) Each plastic packaging or receptacle which is used for liquid hazardous materials must be capable of withstanding without failure the procedure specified in appendix B of this part (``Procedure for Testing Chemical Compatibility and Rate of Permeation in Plastic Packagings and Receptacles''). The procedure specified in appendix B of this part must be performed on each plastic packaging or receptacle used for Packing Group I materials. The maximum rate of permeation of hazardous lading through or into the plastic packaging or receptacles may not exceed 0.5 percent for materials meeting the definition of a Division 6.1 material according to Section 173.132 and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than-

(A) 18 degs.C (64 degs.F) for 180 days in accordance with Test Method 1 in appendix B of this part;

(B) 50 degs.C (122 degs.F) for 28 days in accordance with Test Method 2 in appendix B of this part; or

(C) 60 degs.C (140 degs.F) for 14 days in accordance with Test Method 3 in appendix B of this part.

(iii) Alternative procedures or rates of permeation are permitted if they yield a level of safety equivalent to or greater than that provided by paragraph (e)(3)(ii) of this section and are specifically approved by the Associate Administrator for Hazardous Materials Safety.

(4) Mixed contents. Hazardous materials may not be packed or mixed together in the same outer packaging with other hazardous or nonhazardous materials if such materials are capable of reacting dangerously with each other and causing-

(i) Combustion or dangerous evolution of heat;

(ii) Evolution of flammable, poisonous, or asphyxiant gases;

(iii) Formation of unstable or corrosive materials.

(5) Packagings used for solids, which may become liquid at temperatures likely to be encountered during transportation, must be capable of containing the hazardous material in the liquid state.

(f) Closures. (1) Closures on packagings shall be so designed and closed that under conditions (including the effects of temperature and vibration) normally incident to transportation-

(i) Except as provided in paragraph (g) of this section, there is no identifiable release of hazardous materials to the environment from the opening to which the closure is applied; and

(ii) The closure is secure and leakproof.

(2) Except as otherwise provided in this subchapter, a closure (including gaskets or other closure components, if any) used on a specification packaging must conform to all applicable requirements of the specification.

(g) Venting. Venting of packagings, to reduce internal pressure which may develop by the evolution of gas from the contents, is permitted only when-

(1) Transportation by aircraft is not involved;

(2) Except as otherwise provided in this subchapter, the evolved gases are not poisonous, likely to create a flammable mixture with air or be an asphyxiant under normal conditions of transportation;

(3) The packaging is designed so as to preclude an unintentional release of hazardous materials from the receptacle; and

(4) For shipments in bulk packagings, venting is authorized for the specific hazardous material by a special provision in the Section 172.101 Table or by the applicable bulk packaging specification in part 178 of this subchapter.

(h) Outage and filling limits-(1) General. When filling packagings and receptacles for liquids, sufficient ullage (outage) must be left to ensure that neither leakage nor permanent distortion of the packaging or receptacle will occur as a result of an expansion of the liquid caused by temperatures likely to be encountered during transportation. Requirements for outage and filling limits for non-bulk and bulk packagings are specified in Sections 173.24a(d) and 173.24b(a), respectively.

(2) Compressed gases and cryogenic liquids. Filling limits for compressed gases and cryogenic liquids are specified in Sections 173.301 through 173.306 for cylinders and Sections 173.314 through 173.319 for bulk packagings.

(i) Air transportation. Packages offered or intended for transportation by aircraft must conform to the general requirements for transportation by aircraft in Section 173.27, except as provided in Section 171.11 of this subchapter.

[Amdt. 173-224, 55 FR 52610, Dec. 21, 1990, as amended by Amdt. 173-227, 56 FR 49989, Oct. 2, 1991; 56 FR 66265, Dec. 20, 1991]

Section 173.24a Additional general requirements for non-bulk packagings and packages.

(a) Packaging design. Except as provided in Section 172.312 of this subchapter:

(1) Inner packaging closures. A combination packaging containing liquid hazardous materials must be packed so that closures on inner packagings are upright.

(2) Friction. The nature and thickness of the outer packaging must be such that friction during transportation is not likely to generate an amount of heat sufficient to alter dangerously the chemical stability of the contents.

(3) Securing and cushioning. Inner packagings of combination packagings must be so packed, secured and cushioned to prevent their breakage or leakage and to control their movement within the outer packaging under conditions normally incident to transportation. Cushioning material must not be capable of reacting dangerously with the contents of the inner packagings.

(4) Metallic devices. Nails, staples and other metallic devices shall not protrude into the interior of the outer packaging in such a manner as to be likely to damage inner packagings or receptacles.

(5) Vibration. Each non-bulk package must be capable of withstanding, without rupture or leakage, the vibration test procedure specified in Section 178.608 of this subchapter.

(b) Non-bulk packaging filling limits. (1) A single or composite non-bulk packaging may be filled with a liquid hazardous material only when the specific gravity of the material does not exceed that marked on the packaging, or a specific gravity of 1.2 if not marked, except as follows:

(i) A Packing Group I packaging may be used for a Packing Group II material with a specific gravity not exceeding the greater of 1.8, or 1.5 times the specific gravity marked on the packaging, provided all the performance criteria can still be met with the higher specific gravity material;

(ii) A Packing Group I packaging may be used for a Packing Group III material with a specific gravity not exceeding the greater of 2.7, or 2.25 times the specific gravity marked on the packaging, provided all the performance criteria can still be met with the higher specific gravity material; and

(iii) A Packing Group II packaging may be used for a Packing Group III material with a specific gravity not exceeding the greater of 1.8, or 1.5 times the specific gravity marked on the packaging, provided all the performance criteria can still be met with the higher specific gravity material.

(2) Except as otherwise provided in this section, a single or composite non-bulk packaging may not be filled with a solid hazardous material to a gross mass greater than the maximum gross mass marked on the packaging.

(3) A single or composite non-bulk packaging which is tested and marked for liquid hazardous materials may be filled with a solid hazardous material to a gross mass, in kilograms, not exceeding the rated capacity of the packaging in liters, multiplied by the specific gravity marked on the packaging, or 1.2 if not

marked. In addition:

(i) A single or composite non-bulk packaging which is tested and marked for Packing Group I liquid hazardous materials may be filled with a solid Packing Group II hazardous material to a gross mass, in kilograms, not exceeding the rated capacity of the packaging in liters, multiplied by 1.5, multiplied by the specific gravity marked on the packaging, or 1.2 if not marked.

(ii) A single or composite non-bulk packaging which is tested and marked for Packing Group I liquid hazardous materials may be filled with a solid Packing Group III hazardous material to a gross mass, in kilograms, not exceeding the rated capacity of the packaging in liters, multiplied by 2.25, multiplied by the specific gravity marked on the packaging, or 1.2 if not marked.

(iii) A single or composite non-bulk packaging which is tested and marked for Packing Group II liquid hazardous materials may be filled with a solid Packing Group III hazardous material to a gross mass, in kilograms, not exceeding the rated capacity of the packaging in liters, multiplied by 1.5, multiplied by the specific gravity marked on the packaging, or 1.2 if not marked.

(4) Packagings tested as prescribed in Section 178.605 of this subchapter and marked with the hydrostatic test pressure as prescribed in Section 178.503(a)(5) of this subchapter may be used for liquids only when the vapor pressure of the liquid conforms to one of the following:

(i) The vapor pressure must be such that the total pressure in the packaging (i.e., the vapor pressure of the liquid plus the partial pressure of air or other inert gases, less 100 kPa (15 psi)) at 55 degs.C (131 degs.F), determined on the basis of a maximum degree of filling in accordance with paragraph (d) of this section and a filling temperature of 15 degs.C (59 degs.F)), will not exceed two-thirds of the marked test pressure;

(ii) The vapor pressure at 50 degs.C (122 degs.F) must be less than four-sevenths of the sum of the marked test pressure plus 100 kPa (15 psi); or

(iii) The vapor pressure at 55 degs.C (131 degs.F) must be less than two-thirds of the sum of the marked test pressure plus 100 kPa (15 psi).

(5) No hazardous material may remain on the outside of a package after filling.

(c) Mixed contents. (1) An outer non-bulk packaging may contain more than one hazardous material only when-

(i) The inner and outer packagings used for each hazardous material conform to the relevant packaging sections of this part applicable to that hazardous material;

(ii) The package as prepared for shipment meets the performance tests prescribed in part 178 of this subchapter for the packing group indicating the highest order of hazard for the hazardous materials contained in the package;

(iii) Corrosive materials (except ORM-D) in bottles are further packed in securely closed inner receptacles before packing in outer packagings; and

(iv) For transportation by aircraft, the total net quantity

does not exceed the lowest permitted maximum net quantity per package as shown in Column 9a or 9b, as appropriate, of the Section 172.101 Table. The permitted maximum net quantity must be calculated in kilograms if a package contains both a liquid and a solid.

(2) A packaging containing inner packagings of Division 6.2 materials may not contain other hazardous materials, except dry ice.

(d) Liquids must not completely fill a receptacle at a temperature of 55 degs.C (131 degs.F) or less.

[Amdt. 173-224, 55 FR 52611, Dec. 21, 1990, as amended at 56 FR 66265, Dec. 20, 1991; 57 FR 45460, Oct. 1, 1992]

49 CFR - Transportation
Section 173.25 Authorized packages and overpacks.

(a) Authorized packages containing hazardous materials may be offered for transportation in an overpack as defined in Section 171.8 of this subchapter, if all of the following conditions are met:

(1) The package meets the requirements of Sections 173.21 and 173.24 of this subchapter.

(2) The overpack is marked with the proper shipping name and identification number, and labeled as required by this subchapter for each hazardous material contained therein unless markings and labels representative of each hazardous material in the overpack are visible.

(3) Each package subject to the orientation marking requirements of Section 172.312 of this subchapter is packed in the overpack with its filling holes up and the overpack is marked with package orientation marking arrows on two opposite vertical sides of the overpack with the arrows pointing in the correct direction of orientation.

(4) The overpack is marked with a statement indicating that the inside (inner) packages comply with prescribed specifications when specification packagings are required, unless specification markings on the inside packages are visible.

(5) Packages containing Class 8 (corrosive) materials in Packing Group I or Division 5.1 (oxidizing) materials in Packing Group I may not be overpacked with any other materials.

(b) Shrink-wrapped or stretch-wrapped trays may be used as outer packagings for inner packagings prepared in accordance with the limited quantity provisions or consumer commodity provisions of this subchapter, provided that the complete package is capable of meeting performance standards at the Packing Group III performance level. Each package may not exceed 20 kg (44 lbs) gross weight.

(c) Hazardous materials which are required to be labeled POISON may be transported in the same motor vehicle with material that is marked or known to be foodstuffs, feed or any edible material intended for consumption by humans or animals provided the hazardous material is marked, labeled, and packaged in accordance with this subchapter, conforms to the requirements of paragraph (a) of this section and is overpacked as specified in Section 177.841(e) of this subchapter or in an overpack which is a UN 1A2, 1B2, or 1N2 drum tested and marked for a Packing Group II or higher performance level.

[Amdt. 173-165, 48 FR 28099, June 20, 1983, as amended by Amdt. 173-224, 55 FR 52612 Dec. 21, 1990; 56 FR 66266, Dec. 20, 1991]

(a) Except as provided in paragraph (b) of this section, each package of Class 7 (radioactive) materials offered for transportation must be designed and prepared for shipment, so that under conditions normally incident to transportation, the radiation level does not exceed 2 mSv/hour (200 mrem/hour) at any point on the external surface of the package, and the transport index does not exceed 10.

(b) A package which exceeds the radiation level limits specified in paragraph (a) of this section must be transported by exclusive use shipment, and the radiation levels for such shipment may not exceed the following during transportation:

(1) 2 mSv/h (200 mrem/h) on the external surface of the package unless the following conditions are met, in which case the limit is 10 mSv/h (1000 mrem/h):

(i) The shipment is made in a closed transport vehicle;

(ii) The package is secured within the vehicle so that its position remains fixed during transportation; and

(iii) There are no loading or unloading operations between the beginning and end of the transportation;

(2) 2 mSv/h (200 mrem/h) at any point on the outer surfaces of the vehicle, including the top and underside of the vehicle; or in the case of a flat-bed style vehicle, at any point on the vertical planes projected from the outer edges of the vehicle, on the upper surface of the load or enclosure if used, and on the lower external surface of the vehicle;

(3) 0.1 mSv/h (10 mrem/h) at any point 2 meters (6.6 feet) from the outer lateral surfaces of the vehicle (excluding the top and underside of the vehicle); or in the case of a flat-bed style vehicle, at any point 2 meters (6.6 feet) from the vertical planes projected by the outer edges of the vehicle (excluding the top and underside of the vehicle); and

(4) 0.02 mSv/h (2 mrem/h) in any normally occupied space, except that this provision does not apply to private carriers if exposed personnel under their control wear radiation dosimetry devices as part of a radiation protection program that satisfies the requirements of subpart I of part 172 of this subchapter.

(c) For shipments made under the provisions of paragraph (b) of this section, the offeror shall provide specific written instructions for maintenance of the exclusive use shipment controls to the carrier. The instructions must be included with the shipping paper information. The instructions must be sufficient so that, when followed, they will cause the carrier to avoid actions that will unnecessarily delay delivery or unnecessarily result in increased radiation levels or radiation exposures to transport workers or members of the general public.

(d) Packages exceeding the radiation level or transport index prescribed in paragraph (a) of this section may not be transported by aircraft.

49 CFR - Transportation
Section 173.442 Thermal limitations.

A package of Class 7 (radioactive) material must be designed, constructed, and loaded so that-

(a) The heat generated within the package by the radioactive contents will not, during conditions normally incident to transport, affect the integrity of the package; and

(b) The temperature of the accessible external surfaces of the loaded package will not, assuming still air in the shade at an ambient temperature of 38 degs.C (100 degs.F), exceed either-

(1) 50 degs.C (122 degs.F) in other than an exclusive use shipment; or

(2) 85 degs.C (185 degs.F) in an exclusive use shipment.

6M

49 CFR - Transportation
Section 178.354-1 General requirements.

(a) Each package must meet the applicable requirements of Section 173.24 of this chapter.
(b) [Reserved]

[Amdt. 178-1, 33 FR 14935, Oct. 4, 1968. Redesignated by Amdt. 178-97, 55 FR 52716, Dec. 21, 1990]

49 CFR - Transportation
Section 178.354-2 Rated capacity.

(a) Rated capacity as marked (see Section 178.104-5). Not less than 10 gallons nor more than 110 gallons for the outer steel drum. Not less than 1.24 liters for the inner containment vessel.
(b) [Reserved]

[Amdt. 178-1, 33 FR 14935, Oct. 4, 1968. Redesignated by Amdt. 178-97, 55 FR 52716, Dec. 21, 1990]

49 CFR - Transportation
Section 178.354-3 General construction requirements.

(a) The outer shell must be of straight-sided steel, with welded body seams, and may be either a single sheet of steel, or may be fabricated by welding together two appropriate lengths of drums, such as a DOT Specification 6C or 17C, with each length to contain 3 swedged or rolled rolling hoops as prescribed for either of these specifications. A removable head for a packaging of 210 liters (55 gallons) or larger volume must have one or more corrugations in the cover near the periphery. For a packaging exceeding 57 liters (15 gallons) volume, the head must be crowned (convexed), not extending beyond the level of the chime, with a minimum convexity of 1 centimeter (3/8-inch).
(1) The maximum authorized gross weight, metal thickness, and minimum end insulation thickness for the marked volume is as follows:

Marked capacity		Maximum authorized gross weight	
Gallons not over	Liters	Pounds	Kilograms
15	57	160	73
30	114	480	219
55	210	640	292
110	420	640	292

(2) Each drum must have at least four 1.2 centimeter (0.5-inch) diameter vents near the top, each covered with a weatherproof tape or fusible plug; or equivalent device. A layer of porous refractory fiber may be placed behind the pressure-relief vent holes.

(b) Inner containment vessel must conform to specification 2R or equivalent (cast iron or brass are prohibited), with maximum usable inside diameter of 13.3 centimeters (5.25 inches), minimum usable inside diameter of 10 centimeters (4 inches), and minimum height of 15 centimeters (6 inches).

(c) Inner containment vessel must be fixed within the outer shell by one of the following types of solid centering media, with the sides of the inner vessel protected by at least 9.5 centimeters (3.75 inches) of insulation media, and the ends with at least the thickness as prescribed in Section 178.104-3(a)(1).

(1) Machined discs and rings made of solid industrial cane fiberboard having a density of at least 0.24 g/cc (15 pounds per cubic foot) fitted such that the radial clearances between the fiberboard, inner vessel, and shell do not exceed 6 millimeters (1/4-inch); or

(2) Hardwood or plywood at least 1.2 centimeter (1/2-inch) thick, having a density of at least 0.45 g/cc (28 pounds per cubic foot). There must be no gap or direct heat path from the shell to the inner vessel.

(d) Any radiation shielding material used must be placed within the inner containment vessel or must be protected in all directions by at least the thickness of the thermal insulating material prescribed in paragraph (a) of this section.

(e) For a packaging having an authorized gross weight in excess of 219 kg (480 pounds), a steel bearing plate, at least 6 millimeters (0.25-inch) thick or a plywood disc, at least 2.5 centimeters (1-inch) thick, and at least 25 centimeters (10 inches) in diameter must be provided at both ends and adjacent to the specification 2R inner containment vessel, to provide additional load-bearing surface against the insulation-centering medium.

[Amdt. 178-1, 33 FR 14935, Oct. 4, 1968, as amended by Amdt. 178-35, 39 FR 45246, Dec. 31, 1974; 40 FR 44327, Sept. 26, 1975. Redesignated by Amdt. 178-97, 55 FR 52716, Dec. 21, 1990]

49 CFR - Transportation
Section 178.354-4 Closure.

(a) The outer drum closure must be at least 16-gauge bolt-type locking ring having at least a 5/16-inch steel bolt for drum sizes not over 15 gallons, or a 12-gauge bolted ring with drop-forged lugs, one of which is threaded, and a 5/8-inch steel bolt for drum sizes over 15 gallons. Each bolt must be provided with a lock nut or equivalent device.

(b) The closure device must have means for the attachment of a temperproof lock wire and seal, or equivalent.

[Amdt. 178-1, 33 FR 14935, Oct. 4, 1968. Redesignated by Amdt. 178-97, 55 FR 52716, Dec. 21, 1990]

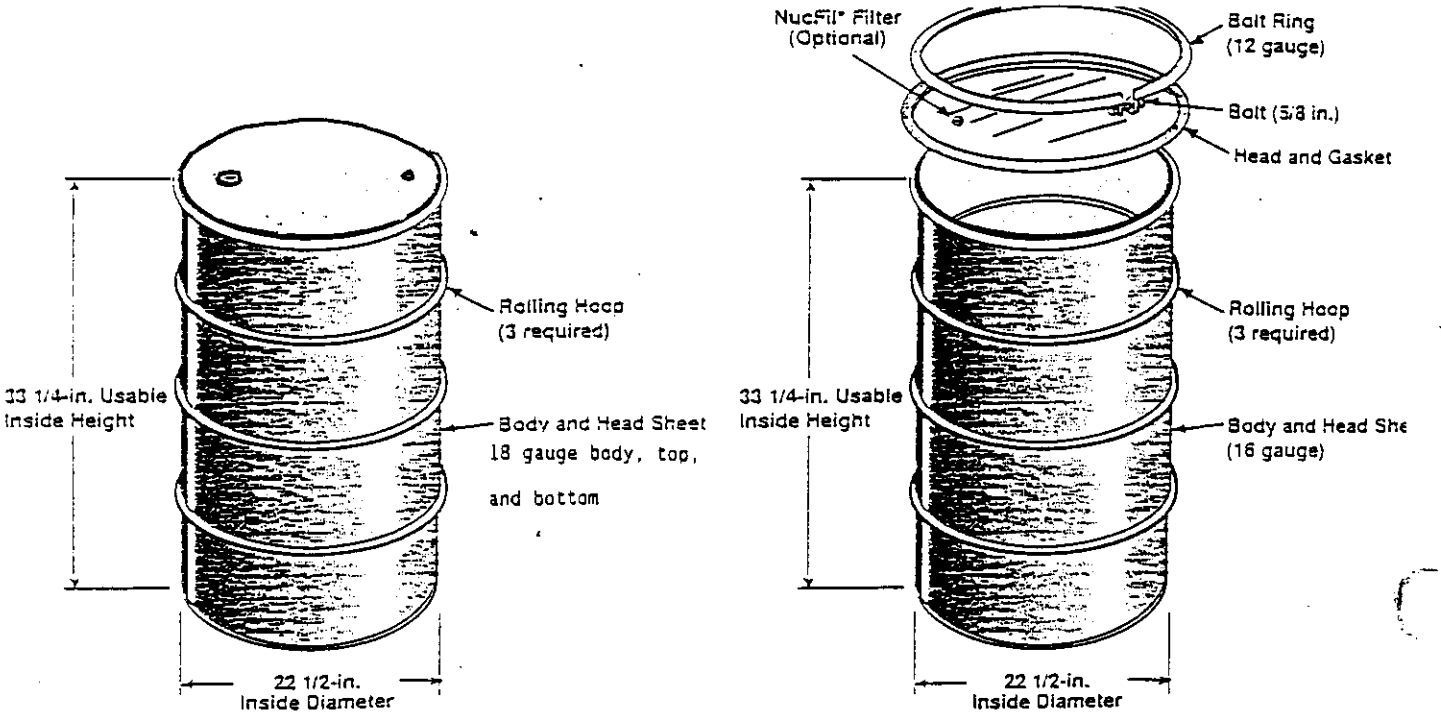
49 CFR - Transportation
Section 178.354-5 Markings.

(a) Marking must be as prescribed in Section 173.24 of this chapter.

(b) Marking on the outside of each package must be as follows: ``DOT-6M Type B,'' ``Radioactive Materials,'' or ``Fissile Radioactive Materials,'' as appropriate; and the gauge of metal of the outer drum in the thinnest part, rated capacity of the outer drum in gallons, and year of manufacture (for example, 18-30-69). When the gauge of the metal in the drum wall differs from that in the head, both must be indicated with a slanting line between, and with the gauge of the body indicated first (e.g., 18/16-55-69 for 18-gauge body and 16-gauge head).

[Amdt. 178-1, 33 FR 14935, Oct. 4, 1968. Redesignated by Amdt. 178-97, 55 FR 52716, Dec. 21, 1990]

LOCKHEED MARTIN IDAHO TECHNOLOGIES PACKAGING AND TRANSPORTATION SAFETY MANUAL	Title: EXAMPLES OF APPROVED PACKAGINGS FOR LIMITED QUANTITY, LOW SPECIFIC ACTIVITY, AND OTHER MATERIALS LISTED IN 49 CFR 172.101 TABLE Section: ADDENDUM H Revision: 0 Revision Date: 06-30-95



Capacity Gal.	Capacity Litres	Measurements Inside	U.S.	Metric	Weight & Gauge U.S.	Metric	Style	U.S. DOT	UN
8	30	Diameter Height	13.87" 14.00"	35 cm 36 cm	12 lbs. 20 gauge	5 kg 0.90 mm	Open Head	17C	1A2/X
10	38	Diameter Height	13.87" 17.00"	35 cm 43 cm	14 lbs. 20 gauge	6 kg 0.90 mm	Open Head	17C	1A2/X
20	76	Diameter Height	18.25" 19.25"	46 cm 49 cm	30 lbs. 18 gauge	14 kg 1.20 mm	Open Head	17C 17E	1A2/X 1A1/X
30	114	Diameter Height	18.25" 27.50"	46 cm 70 cm	35 lbs. 18 gauge	16 kg 1.20 mm	Open Head	17C 17E	1A2/X 1A1/X
→ 55	208	Diameter Height	22.50" 33.00"	57 cm 84 cm	60 lbs. 16 gauge	27 kg 1.50 mm	Open Head	17C 17E	1A2/X 1A1/X
79	299	Diameter Height	26.00" 33.76"	66 cm 86 cm	72 lbs. 16 gauge	33 kg 1.50 mm	Open Head	CFR49 Sec. 173.3	1A2/X
85	322	Diameter Height	26.00" 37.00"	66 cm 92 cm	80 lbs. 16 gauge	35 kg 1.50 mm	Open Head	CFR49 Sec. 173.3	1A2/X
96	363	Diameter Height	26.00" 41.00"	66 cm 104 cm	85 lbs. 16 gauge	39 kg 1.50 mm	Open Head	CFR49 Sec. 173.3	1A2/X
110	416	Diameter Height	30.00" 41.00"	76 cm 104 cm	102 lbs. 16 gauge	46 kg 1.50 mm	Open Head	CFR49 Sec. 173.3	1A2/X

Note: These drums may also be used for other materials listed in the 172.101 table that are not radioactive.

Figure H-1.

APPENDIX B

GAMMA EXPOSURE ESTIMATE

SIDE DOSE

MicroShield 4.21 - Serial #4.21-01037
Lockheed Idaho Technologies Company for US DOE

Page : 1
DOS File: ARMF1.MS4
Run Date: May 10, 1996
Run Time: 8:09 a.m. Friday
Duration: 0:00:28

File Ref:
Date: 5/10/96
By: Scott Zeller
Checked: W.D. Wagner

Case Title: ARMF1

GEOMETRY 7 - Cylinder Volume - Side Shields

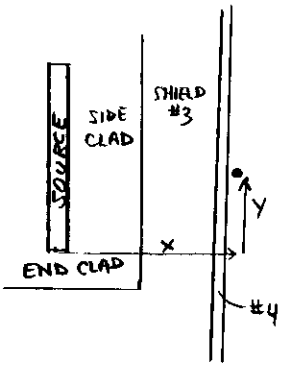
	centimeters	feet and inches	
Dose point coordinate X:	29.21	0.0	11.5
Dose point coordinate Y:	11.43	0.0	4.5
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	22.86	0.0	9.0
Cylinder radius:	1.27	0.0	.5
Shield 3:	13.335	0.0	5.3
Shield 4:	0.16	0.0	.1
Air Gap:	2.38	0.0	.9
Side Clad:	12.065	0.0	4.7
End Clad:	7.62	0.0	3.0

Source Volume: 115.833 cm^3 4.09062e-3 cu ft. 7.06858 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 3 Cylinder	Shield 4 Cylinder	Transition Shield	Air Gap
Air				0.00122	0.00122
Carbon		0.32			
Iron			7.86		
Radium	5.0				

Material	Side Clad Shield	End Clad Shield
Iron	7.86	7.86



BUILDUP
Method: Buildup Factor Tables
The material reference is Air Gap

INTEGRATION PARAMETERS

	Quadrature Order
Radial	10
Circumferential	10
Y Direction (axial)	20

SOURCE NUCLIDES - 660 mCi decayed 23 yrs.

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Bi-210	3.3516e-001	2.8935e+003	Bi-214	6.5333e-001	5.6403e+003
Pb-210	3.3536e-001	2.8952e+003	Pb-214	6.5333e-001	5.6403e+003
Po-210	3.2965e-001	2.8459e+003	Po-214	6.5319e-001	5.6391e+003

DOS File: ARMF1.MS4
Run Date: May 10, 1996
Run Time: 8:09 a.m. Friday
Title : ARMF1

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Po-218	6.5346e-001	5.6414e+003	Ra-226	6.5346e-001	5.6413e+003
Rn-222	6.5346e-001	5.6414e+003			

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.05	7.697e+008	5.396e-078	7.223e-020	1.437e-080	1.924e-022
0.08	5.573e+009	1.778e-021	6.978e-017	2.814e-024	1.104e-019
0.1	3.281e+007	1.780e-014	1.941e-010	2.723e-017	2.970e-013
0.2	2.604e+009	2.447e-003	1.413e+000	4.319e-006	2.494e-003
0.3	4.988e+009	4.423e-001	7.965e+001	8.390e-004	1.511e-001
0.4	9.250e+009	7.903e+000	6.923e+002	1.540e-002	1.349e+000
0.5	4.318e+008	1.565e+000	8.241e+001	3.072e-003	1.618e-001
0.6	1.166e+010	1.192e+002	4.274e+003	2.327e-001	8.343e+000
0.8	2.284e+009	1.008e+002	2.098e+003	1.918e-001	3.991e+000
1.0	7.569e+009	9.317e+002	1.329e+004	1.717e+000	2.450e+001
1.5	4.602e+009	2.926e+003	2.328e+004	4.922e+000	3.916e+001
2.0	6.469e+009	1.073e+004	6.144e+004	1.660e+001	9.502e+001
TOTAL:	5.623e+010	1.482e+004	1.052e+005	2.368e+001	1.727e+002

TOP DOSE

MicroShield 4.21 - Serial #4.21-01037
Lockheed Idaho Technologies Company for US DOE

Page : 1
DOS File: ARMFEND.MS4
Run Date: May 10, 1996
Run Time: 8:32 a.m. Friday
Duration: 0:00:09

File Ref:
Date: 5/10/96
By: Scott LaBay
Checked: W. D. Wayne

Case Title: ARMFEND

GEOMETRY 8 - Cylinder Volume - End Shields

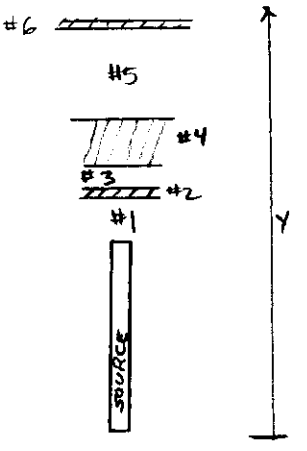
	centimeters	feet and inches	
Dose point coordinate X:	0.0	0.0	.0
Dose point coordinate Y:	60.96	2.0	.0
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	22.86	0.0	9.0
Cylinder radius:	1.905	0.0	.8
Shield 1:	11.43	0.0	4.5
Shield 2:	1.27	0.0	.5
Shield 3:	2.54	0.0	1.0
Shield 4:	6.985	0.0	2.8
Shield 5:	13.335	0.0	5.3
Shield 6:	0.16	0.0	.1
Air Gap:	2.38	0.0	.9

Source Volume: 260.625 cm^3 9.20388e-3 cu ft. 15.9043 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Shield 2 Slab	Shield 3 Slab	Shield 4 Slab
Air		0.00122		0.00122	
Iron			7.86		7.86
Radium	5.0				

Material	Shield 5 Slab	Shield 6 Slab	Air Gap
Air			0.00122
Carbon	0.32		
Iron		7.86	



BUILDUP
Method: Buildup Factor Tables
The material reference is Air Gap

INTEGRATION PARAMETERS

	Quadrature Order
Radial	20
Circumferential	10
Y Direction (axial)	10

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3

DOS File: ARMFEND.MS4
Run Date: May 10, 1996
Run Time: 8:32 a.m. Friday
Title : ARMFEND

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Bi-210	3.3516e-001	1.2860e+003	Bi-214	6.5333e-001	2.5068e+003
Pb-210	3.3536e-001	1.2867e+003	Pb-214	6.5333e-001	2.5068e+003
Po-210	3.2965e-001	1.2648e+003	Po-214	6.5319e-001	2.5063e+003
Po-218	6.5346e-001	2.5073e+003	Ra-226	6.5346e-001	2.5073e+003
Rn-222	6.5346e-001	2.5073e+003			

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.05	7.697e+008	2.777e-054	2.765e-020	7.396e-057	7.365e-023
0.08	5.573e+009	5.855e-015	5.581e-011	9.265e-018	8.832e-014
0.1	3.281e+007	7.903e-011	2.600e-007	1.209e-013	3.978e-010
0.2	2.604e+009	1.403e-002	3.227e+000	2.476e-005	5.695e-003
0.3	4.988e+009	8.825e-001	7.399e+001	1.674e-003	1.404e-001
0.4	9.250e+009	1.029e+001	4.760e+002	2.006e-002	9.275e-001
0.5	4.318e+008	1.640e+000	5.008e+001	3.220e-003	9.831e-002
0.6	1.166e+010	1.096e+002	2.447e+003	2.138e-001	4.777e+000
0.8	2.284e+009	7.860e+001	1.119e+003	1.495e-001	2.129e+000
1.0	7.569e+009	6.509e+002	6.745e+003	1.200e+000	1.243e+001
1.5	4.602e+009	1.696e+003	1.074e+004	2.853e+000	1.807e+001
2.0	6.469e+009	5.448e+003	2.611e+004	8.425e+000	4.037e+001
TOTAL:	5.623e+010	7.996e+003	4.776e+004	1.287e+001	7.895e+001

Bottom Dose

MicroShield 4.21 - Serial #4.21-01037
Lockheed Idaho Technologies Company for US DOE

Page : 1
DOS File: ARMFEND.MS4
Run Date: May 10, 1996
Run Time: 8:35 a.m. Friday
Duration: 0:00:09

File Ref:
Date: 5/10/96
By: Scott LaBay
Checked: W.D. Wagner

Case Title: ARMFEND

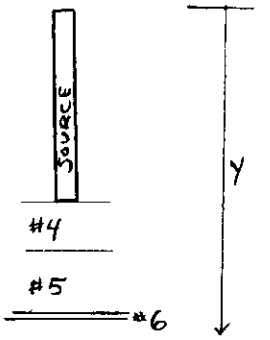
GEOMETRY 8 - Cylinder Volume - End Shields

	centimeters	feet and inches	
Dose point coordinate X:	0.0	0.0	.0
Dose point coordinate Y:	46.99	1.0	6.5
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	22.86	0.0	9.0
Cylinder radius:	1.905	0.0	.8
Shield 4:	9.525	0.0	3.8
Shield 5:	13.335	0.0	5.3
Shield 6:	0.16	0.0	.1
Air Gap:	1.11	0.0	.4

Source Volume: 260.625 cm^3 9.20388e-3 cu ft. 15.9043 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 4 Slab	Shield 5 Slab	Shield 6 Slab	Air Gap
Air					0.00122
Carbon			0.32		
Iron		7.86		7.86	
Radium	5.0				



BUILDUP
Method: Buildup Factor Tables
The material reference is Air Gap

INTEGRATION PARAMETERS

	Quadrature Order
Radial	20
Circumferential	10
Y Direction (axial)	10

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Bi-210	3.3516e-001	1.2860e+003	Bi-214	6.5333e-001	2.5068e+003
Pb-210	3.3536e-001	1.2867e+003	Pb-214	6.5333e-001	2.5068e+003
Po-210	3.2965e-001	1.2648e+003	Po-214	6.5319e-001	2.5063e+003
Po-218	6.5346e-001	2.5073e+003	Ra-226	6.5346e-001	2.5073e+003
Rn-222	6.5346e-001	2.5073e+003			

DOS File: ARMFEND.MS4
Run Date: May 10, 1996
Run Time: 8:35 a.m. Friday
Title : ARMFEND

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.05	7.697e+008	6.215e-062	5.649e-020	1.656e-064	1.505e-022
0.08	5.573e+009	5.738e-017	8.610e-013	9.080e-020	1.362e-015
0.1	3.281e+007	6.257e-012	3.129e-008	9.572e-015	4.788e-011
0.2	2.604e+009	8.633e-003	2.696e+000	1.524e-005	4.759e-003
0.3	4.988e+009	7.435e-001	8.027e+001	1.410e-003	1.523e-001
0.4	9.250e+009	9.944e+000	5.725e+002	1.938e-002	1.115e+000
0.5	4.318e+008	1.723e+000	6.391e+001	3.382e-003	1.254e-001
0.6	1.166e+010	1.221e+002	3.248e+003	2.383e-001	6.339e+000
0.8	2.284e+009	9.529e+001	1.574e+003	1.813e-001	2.994e+000
1.0	7.569e+009	8.369e+002	9.882e+003	1.543e+000	1.822e+001
1.5	4.602e+009	2.395e+003	1.677e+004	4.029e+000	2.821e+001
2.0	6.469e+009	8.126e+003	4.233e+004	1.257e+001	6.546e+001
TOTAL:	5.623e+010	1.159e+004	7.452e+004	1.858e+001	1.226e+002

APPENDIX C

NEUTRON EXPOSURE ESTIMATE

DATE: 4/10/96
BY: S. LaBar
CHECKED: W. D. Wagner

CALCULATE THE NEUTRON DOSE FROM THE ARMF RADIOACTIVE SOURCES

SOURCES: 1) RaBe – 594 mCi
2) RaBe – 55 mCi
3) AmBe – 10 mCi
4) AmBe – 10 mCi

Reaction: $Be(\alpha, n)C$

NEUTRON GENERATION RATE: RaBe – 1.3×10^7 n/s per Ci
AmBe – 2.2×10^6 n/s per Ci

REF: "THE HEALTH PHYSICS AND RADIOLOGICAL HEALTH HANDBOOK", 1992, page 228.

$$1.3\times10^7 \frac{n/s}{Ci} \times (0.594+0.055)Ci + 2.2\times10^6 \times (0.01+0.01) = 8.48\times10^6 \, n/s$$

THE UNSHIELDED NEUTRON FLUX AT THE DRUM SURFACE IS: R = 11.5 in.

$$\phi = \frac{n/s}{4\pi R^2} = \frac{8.48\times10^6}{4\pi\left(11.5 \text{ in } 2.54\frac{cm}{in}\right)^2} = 791 \; n/cm^2\cdot s$$

Using $7 \; n/cm^2\cdot s = 1 \text{ mrem/hr}$, RESULTS IN 113 mrem/hr unshielded.

↑
REF: "INTRODUCTION TO NUCLEAR ENGINEERING", LaMarsh.

THE SHIELDED NEUTRON FLUX AT THE DRUM SURFACE IS:

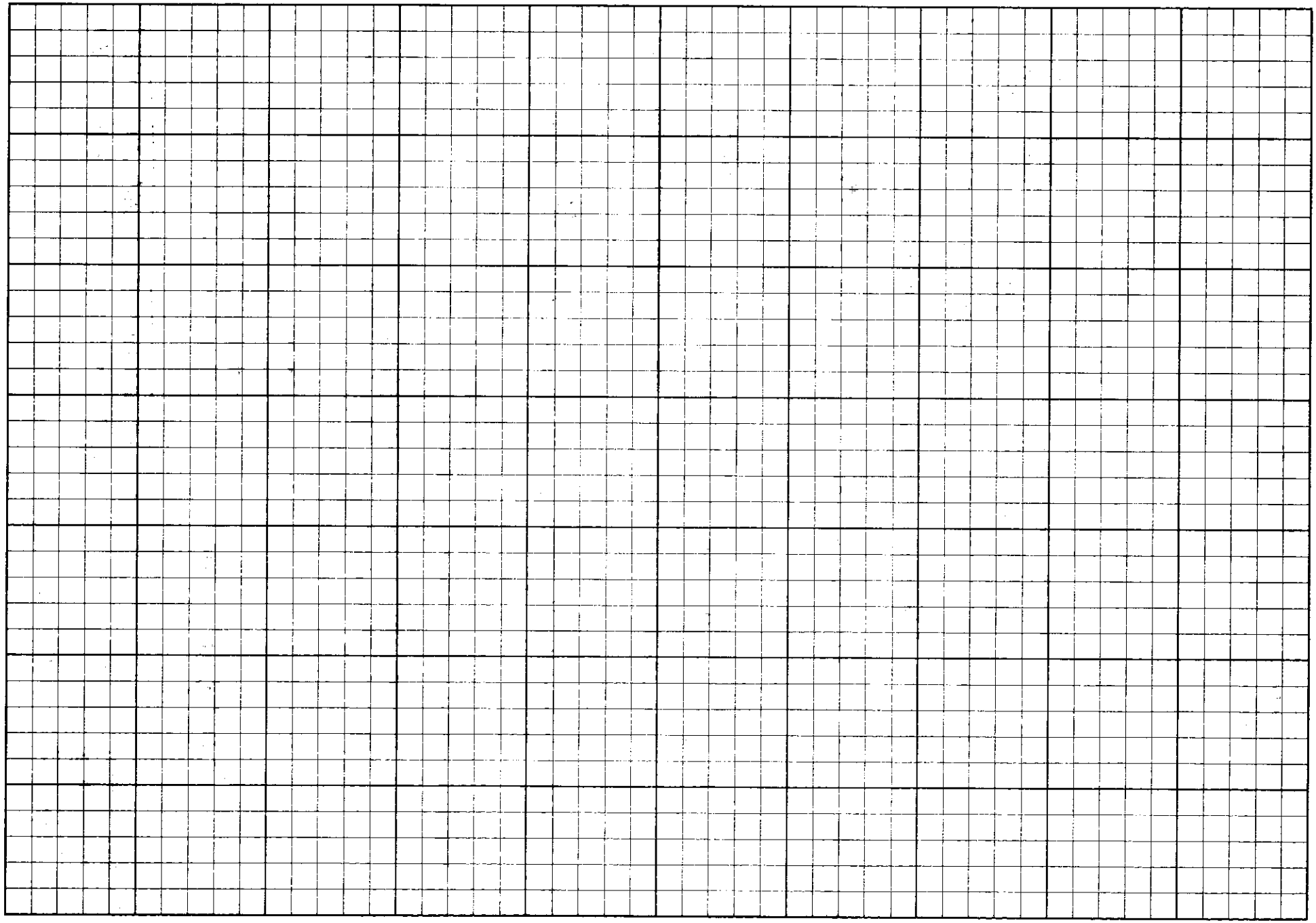
$$\phi = \frac{SA}{4\pi R^2} e^{-\Sigma_R t}$$

t = 4.75 in. steel
Σ_R = 0.168 for steel
R = 11.5 in.
S = 8.48×10^6 n/s
A = 0.12 (constant)

$$= \frac{(8.48\times10^6 \, n/s)\,0.12}{4\pi\,(11.5(2.54))^2} e^{-(0.168)(12.1)}$$

$$= 12.5 \; n/cm^2\cdot s$$

Using $7 \; n/cm^2\cdot s = 1 \text{ mrem/hr}$, RESULTS IN **2 mrem/hr neutron dose**



APPENDIX D

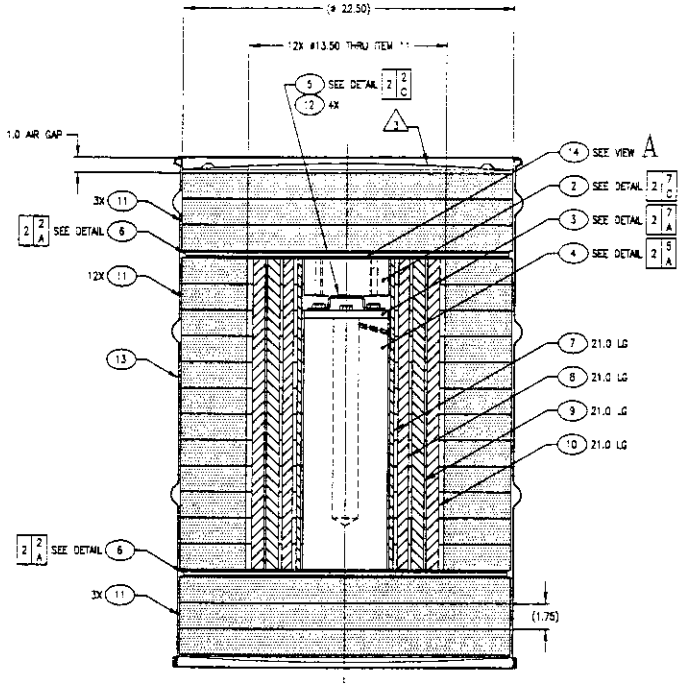
DESIGN DRAWINGS

NOTES:

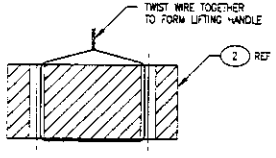
1. REMOVE ALL BURRS AND SHARP EDGES.
2. CLEANLINESS PER STD-7022, LEVEL C.
3. MARK PER STD-7006-302 WITH 453095-1 ASSEMBLY USING .25 HIGH CHARACTERS.
4. DRUM VENT ("NUCFIL" OR APPROVED EQUAL) SHALL BE INSTALLED BY OPERATIONS PRIOR TO SHIPMENT.

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED

SHEET	REV STATUS OF SHEETS
2	-
-	1
REVISION	



-1 ASSEMBLY
SCALE: 1/4



VIEW A
SCALE: 1/2

ITEM/FIND	DESCRIPTION/MATERIAL/SPECIFICATION	PART OR IDENTIFYING NO.	QUAL. LEVEL	-1	QTY DETAIL
14	WIRE			AR	2
13	DRUM, 55 GALLON W/LID	UN1A2		1	2
12	BOLT, HEX HEAD 1/2-13 UNC-2A X 1.5 LONG			4	2
11	FIBERBOARD, STANDARD INDUSTRIAL CANE 22 1/2 DIA X 1 3/4 THK			AR	2
10	SHIELD			AR	2
9	SHIELD			AR	2
8	SHIELD			AR	2
7	SHIELD			AR	2
6	BEARING PLATE	-6		2	2
5	HANDLE	-5		1	2
4	STORAGE CAN	-4		1	2
3	STORAGE CAN LID	-3		1	2
2	SHIELD PLUG	-2		1	2
1	ASSEMBLY	-1			2

DESCRIPTION		
WIRE	CS, 14 GA TO 18 GA	
DRUM, 55 GALLON W/LID		
BOLT, HEX HEAD 1/2-13 UNC-2A X 1.5 LONG	CS ASTM A325	
FIBERBOARD, STANDARD INDUSTRIAL CANE 22 1/2 DIA X 1 3/4 THK		
SHIELD	PIPE, 12 SCH 100 CS ASTM A53	
SHIELD	PIPE, 10 SCH 120 CS ASTM A53	
SHIELD	PIPE, 8 SCH 120 CS ASTM A53	
SHIELD	PIPE, 6 SCH 40 CS ASTM A53	
BEARING PLATE	PLATE, 1/4 THK CS ASTM A36	
HANDLE	PLATE OR SHEET, 1/8 THK CS ASTM A36	
STORAGE CAN	BAR, 5 3/4 DIA SST ASTM A276	
STORAGE CAN LID	PLATE, 1/2 THK SST ASTM A178	
SHIELD PLUG	BAR, 5 3/4 DIA SST ASTM A276	

PARTS LIST

DIMENSIONING AND SYMBOLOGY ARE AMERICAN NATIONAL STANDARD UNLESS OTHERWISE SPECIFIED
SURFACE ROUGHNESS 125
DIMENSIONS AND TOLERANCES ARE IN INCHES
TOLERANCES: .X ± .1, .XX ± .03, .XXX ± .010
FRACTIONS ± 1/8
ANGLES ± 1°
DO NOT SCALE DRAWING

NEXT ASSY/REF DWG

FINAL

DESIGN		DATE
DRAWN	B. RHODES	DATE MAY '96
RELEASE		DATE

Lockheed Idaho Technologies Company

ARMF TRU
SHIPPING DRUM

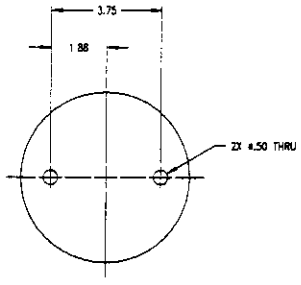
SIZE D | CAGE CODE 0981 | DRAWING NO. 453095 | REV -
SCALE NOTED | SHEET 1 OF 2

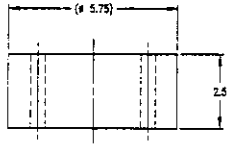
PROJECT NO. 168764 | CAGE CODE | 1 TBA TD-1367

AUDIT'S NO.

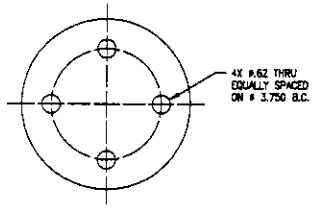
File: 453095I.DWG
User ID: (EBR)E:\EBR\
Date: 05/15/98
Time: 4:25 P.M.

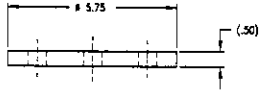
REVISIONS			
REV	DESCRIPTION	DATE	APPROVED





DETAIL (2)
SCALE: 1/2





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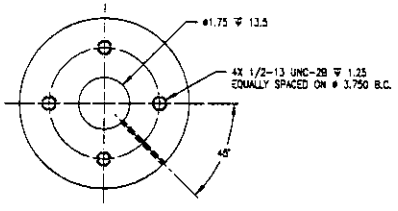

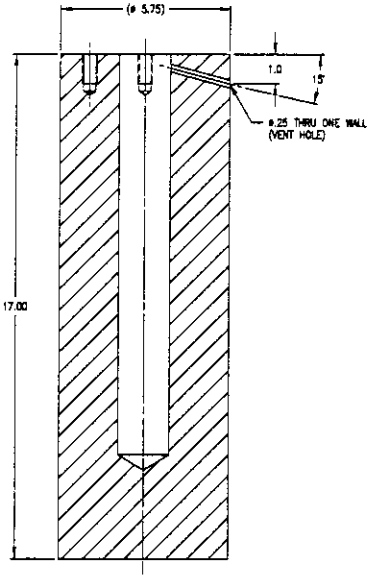

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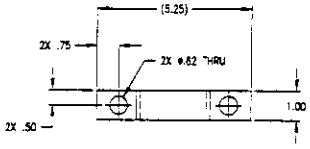

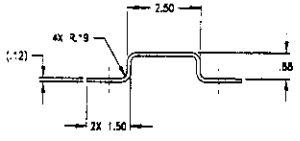

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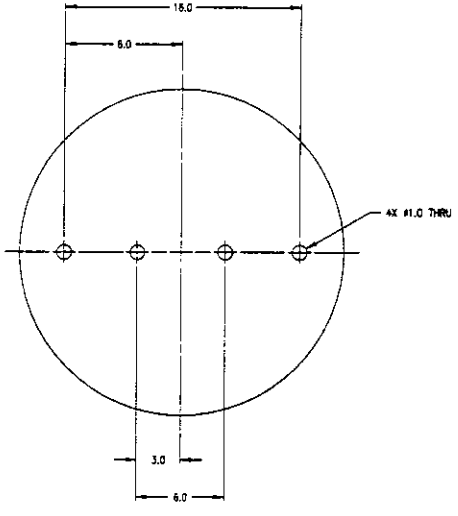

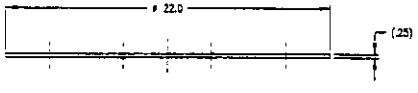

DETAIL (6)
SCALE: 1/4

SIZE	FSCM NO.	DRAWING NO.	REV
D	98.89991	453095	
SCALE: NOTED		SHEET 2	

1 TBA TD-1367

ADDED ON SCREW

File: 453095B2.DWG
Layer ID: (EBR)C:\EBR\
Date: 05/15/98
Time: 4:38 P.M.

APPENDIX E

FABRICATION INSPECTION PLAN

EG&G Idaho, Inc.

FORM EG&G-573C (Rev. 10-90)

INSPECTION INSTRUCTIONS

Planning/Requisition No.: ARMF TRU Shipping	Rev. No.: 0	Line Item No.:	Quantity: Quality Level: 1
Title/Description: ARMF TRU Shipping Drum Parts and Assembly		Dwg. No.: 453095	Rev. No.:
		ARMF TRU Shipping Drum - Assembly	Rev. No.:
Ray R Williams R. R. Williams Prepared By	5/14/96 Date	Scott a Labuy Scott Labuy Program Concurrence	5/14/96 Date
		Q.A. Code No.:	
		Final Inspection Review:	Date:

CHAR. NO.	INSP. REQ.	INSPECTION CHARACTERISTIC	NOTES/TOOLS	INSPECTION STATUS STAMP/DATE
1	Yes	Verify dimensions of the following: (tolerances defined in schedule on ARMF TRU Shipping Drum - assembly schedule drawing # 453095).		
a.		Item 13 Drum UN1A2 55 gal w/lid		
b.		Item 12 Bolt hex head		
c.		Item 11 Fiber board standard industrial can 22-1/2 diam. X 1-3/4 thick		
d.		Item 10 Shield pipe 12" sched 100 C.S.		
e.		Item 9 Shield pipe 10" sched 120 C.S.		
f.		Item 8 Shield pipe 8" sched. 120 C.S.		
g.		Item 7 Shield pipe 6" sched. 40 C.S.		
h.		Item 6 Plate Bearing 1/4" thick X 22" diam.		
i.		Item 5 Handle C.S. to drawing		
j.		Item 4 Storage can Bar 5-3/4" diam. SST		
k.		Item 3 Lid storage can plate 1/2" SST		
l.		Item 2 Bar 5-3/4" diam. X 1/2" thick		
m.		Spacers 12 - 1-3/4" thick 13.5" ID 22.5" OD		
2.		Verify assembly per Drawing ARMF TRU Shipping Drum 453095		

APPENDIX F

DRAFT DRUM LOADING PROCEDRURE

LOCKHEED MARTIN

Lockheed Idaho Technologies Company

FORM INEL-101# (Rev. 08-95)

Technical Procedure ARMF/CFRMF	ARMF/CFRMF SOURCE REMOVAL	Identifier: TPR-727 Revision: DRAFT Page: 1 of 5
Doc. Control Center ( )	Doc. Owner/Approver:	Eff. Date:

Change Notice No. _____

1.0 INTRODUCTION

The purpose of this procedure is to remove, package, and ship the radioactive sources from located in the ARMF water canal.

2.0 PRECAUTIONS AND LIMITATIONS

2.1 All work in this procedure shall be covered by a Radiological Work Permit.

2.2 All hand tools and other small objects capable of falling into the canal shall be secured by lanyards, or other suitable means.

2.3 Ensure the radiological sources are monitored by the RCT as they approach the surface of the canal.

2.4 The TRA-660 roof ventilator shall not be operated during radiological source handling.

2.5 A qualified radiological source handler shall be present during source handling.

3.0 PREREQUISITES

___ 3.1 Arrange for RCT coverage of the job.

___ 3.2 Arrange three days in advance for a representative from RWMC to be present.

___ 3.3 Inspect the shipping drum and storage container.

___ 3.4 Perform a pre-job briefing prior to start of Section 4.0.

3.5 The following tools, equipment, and parts are required:

3.5.1 Approved shipping package.

3.5.2 Wire snips.

3.5.3 Pull wire and wooden dowels for handles.

3.5.4 Electric or air driven wrench and socket for inner container lid.

3.5.5 Remote handled pliers.

3.5.6 Clean container with small holes in bottom i.e. a new paint can.

3.5.7 White 1/8" or larger nylon rope/cord.

3.5.8 Tamper indicating device.

3.5.9 Torque wrench with 100 ft-lb range, as necessary.

___ 3.6 Notify TRA shipper 3 days in advance of shipment.

4.0 INSTRUCTIONS

4.1 Remove and Package the 600 mCi RaBe Source

___ 4.1.1 Attach a pull wire around the 600 mCi RaBe, Ser. # M-3RA001, source wire securing a quick link around the source wire with the pull wire attached to the quick link. (Estimated dose rate of 6 R/hr @ 1 ft. in air)

4.1.2 Attach the wooden dowels to the pull and source wire, where appropriate, for handles.

4.1.3 Secure the end of the source wire to prevent loss of the wire and source should it be dropped.

4.1.4 Position a person on the CFRMF bridge with hold of the source wire and handle. Position a person on the ARMF bridge with hold of the pull wire and handle.

NOTE: *Perform 4.1.5 - 4.1.8 steps as a single movement to minimize radiation exposure.*

4.1.5 CFRMF OPERATOR: Lift the 600 mCi source toward the surface of the canal with the source wire.

4.1.6 ARMF OPERATOR: Keep light tension on the pull wire.

4.1.7 When the source is out of the water and above the level of the collimator

platform: ARMF OPERATOR: Pull the source over the collimator platform and the blotting paper.

4.1.8 Lower the source to the blotting paper and allow it dry.

NOTE: *Maintain maximum distance as directed by the RCT to minimize exposure.*

4.1.9 When the source is dry, as determined by the Job Supervisor, place the source into the storage container by lifting the source with both wires.

4.1.10 Remove the pull wire by pulling it away from the container. Maintain the source wire attached so the source can be moved while inserting the other sources.

4.2 **Remove and Package the 60 mCi RaBe Source**

4.2.1 Attach about 20' of nylon cord and a pull wire to the clean secondary container as appropriate. Secure the end of the nylon cord so the container and cord cannot be lost if the source is dropped.

4.2.2 Position a person on the ARMF platform with the container and cord and a second operator on the CFRMF with the secondary container pull wire.

—— 4.2.3 Sink the container into the canal next to the 60 mCi source Ser # M-3RA002.

4.2.4 Lift the small open source container with the 60 mCi source, over and into the secondary container.

4.2.5 Lift the secondary container out of the water and allow the secondary container to drain.

4.2.6 Pull the 60 mCi source in the secondary container to the collimator platform. (Estimated dose rate of 0.5 R/hr @ 1 ft. in air)

4.2.7 Set the secondary container on the blotting paper.

4.2.8 Remove the loose source from its open holding can onto the blotter paper with the remote handled pliers. Allow the source to dry.

4.2.9 When the source is dry, as determined by the job supervisor, place the

source into the inner container.

4.3 Remove and Package the AmBe Sources

4.3.1 Remove one AmBe source at a time from the storage cabinet. Place each source in the inner container using the remote handled pliers. Move the sources in the inner container as needed to allow the AmBe sources to fit.

4.4 Close and package the inner container

4.4.1 Cut the wire from the 600mCi RaBe source with a wire cutter, at a distance of approximately 12 inches from the container.

NOTE: *The thin wires will be pinched by the lid and do not interfere with the lid integrity.*

4.4.2 Place the lid on the container, insert bolts, and tighten.
(Estimated dose rate of 11 R/hr @ contact with the midheight sides of container, 6 R/hr near the top edges of the container, and 0.9 R/hr @ 1 ft from the midheight of the container)

4.4.3 Place the 120 lb. container into the 55 gal. drum.

4.4.4 Place the shield plug onto the container. Install the steel bearing plate. Inspect and install the remaining fiberboard pieces, the drum lid, drum vent, and closure ring.

4.4.5 Torque the ring clamp bolt to 40-45 ftlbs

_____ Date _____
Signature

4.4.6 Safeguards and Security install the Tamper Indicating Device.

4.4.7 **RCT:** Perform surveys as required. (The estimated dose rate external to the drum is less than 200 mR/hr)

4.5 Ship drum

4.5.1 Complete shipping papers.

4.5.2 Load drum on the truck and secure per requirements.

5.0 POST PERFORMANCE ACTIVITIES

5.1 Cleanup, store tools and rigging.

6.0 DOCUMENTATION

NONE

7.0 SOURCE REQUIREMENTS

NONE

8.0 APPENDICES

NONE